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4 Oct 1893

STATE OF VERMONT

FIFTH ANNUAL REPORT

OF THE

STATE AGRICULTURAL EXPERIMENT STATION.

1891.

BURLINGTON:
THE FREE PRESS ASSOCIATION.
1892.

STATE OF VERMONT.

FIFTH

ANNUAL REPORT

OF THE

STATE AGRICULTURAL

EXPERIMENT STATION.

1891.

BURLINGTON:
FREE PRESS ASSOCIATION, Printers and Binders.
1892.

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THE VERMONT STATE

Agricultural * Experiment * Station.

BURLINGTON, VT.

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W. W. COOKE	Director.
J. L. HILLS	Chemist.
L. R. JONES	Botanist.
G. H. PERKINS	Entomologist.
F. A. RICH	Veterinarian.
B. O. WHITE	Asst. Chemist.
D. D. HOWE	Farm Supt.
F. G. A. KULLANDER	Dairyman.
CORA F. MARSH	Stenographer.
E. H. POWELL	Treasurer.

ANNOUNCEMENT.

———:o:———

The Vermont State Agricultural Experiment Station was established in accordance with an Act of the General Assembly approved Nov. 24th, 1886, for the purpose of promoting agriculture by scientific investigation and experiment.

The Station is prepared to analyze and test fertilizers, cattle foods, seeds, soils, milk and other agricultural materials and products, to identify grasses, weeds and useful or injurious insects, and to give information on various subjects of agricultural science for the use and advantage of the citizens of Vermont.

All chemical analyses, seed investigations, etc., proper to an experiment station, that can be used for the public benefit, will be made without charge. The Station will undertake no work the results of which are not at its disposal to use or publish if deemed advisable for the public good. The results of each analysis or examination will be promptly communicated to the party sending the sample. Those that are of general interest will be published in bulletins, copies of which will be sent to each post office in the State. The work of the year will be summed up in the annual report of the Station.

It is the wish of the Board of Control to make the Station as widely useful as its resources will admit. Every Vermont citizen who is concerned in agriculture, whether farmer, manufacturer or dealer, has the right to apply to the Station for any assistance that comes within its province to render, and the Station will respond to all applications as far as it lies in its power. All communications on agricultural and horticultural topics will be fairly considered and as far as possible promptly answered. Any one desiring to send samples or specimens for examination should first write to the Experiment Station and get blanks and directions for taking samples.

Parcels by express, to receive attention, should be prepaid.

The Station offices and laboratory are in the Station Building, corner of Main street and University Place. The Station farm buildings, stock, creamery and greenhouse are a short distance eastward on the Williston road. The Station has telephone connection and may be spoken from the Central Telephone Office and any Hotel in Burlington, and from the telephone stations at Winooski, Essex Junction, Richmond, Charlotte, Shelburne, Vergennes and Montpelier.

W. W. COOKE, Director,
Burlington, Vt.

☞Address all communications, not to any individual officer, but to the Agricultural Experiment Station, Burlington, Vt.

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FINANCIAL REPORT

FOR THE FISCAL YEAR ENDING JUNE 30, 1891.

The State Agricultural Experiment Station

OF VERMONT

In Account with the United States.

DR.		
To appropriation		$15,000 00
CR.		
By Salaries	$5,036 01	
" Labor	3,054 88	
" Buildings	249 99	
" Water, gas, fuel and telephone	609 47	
" Library	41 55	
" Apparatus	413 08	
" Chemicals	161 52	
" Horticultural supplies	292 20	
" Vehicles and team implements	78 29	
" Tools and farm implements	299 39	
" Stationery, postage and telegrams	318 00	
" Printing	852 26	
" Live stock	498 40	
" Traveling expenses	488 29	
" Furniture	171 00	
" Freight, cartage and express	417 69	
" Incidentals	539 67	
" Supplies	1,478 31	
		$15,000 00

We, the undersigned, duly appointed auditors for the corporation, hereby certify that we have examined the books and accounts of the Experiment Station of the University of Vermont and State Agricultural College, for the fiscal year ending June 30, 1891; that we have found the same well kept, and correctly classified as above, and that the receipts for the time named are shown to have been $15,000.00, and the corresponding disbursements $15,000.00 for all of which proper vouchers are on file, and have been by us examined and found correct.

M. H. BUCKHAM,
CASSIUS PECK,
G. S. FASSETT,

Auditing Committee of the Board of Trustees.

I hereby certify that the foregoing statement of account, to which this is attached, is a true statement from the books of account of the institution named.

HENRY O. WHEELER,
Treasurer.

{ SEAL. }

We, the undersigned, do hereby certify that the above is the signature of H. O. Wheeler, treasurer of the University of Vermont and State Agricultural College, and that the above is the seal of said institution.

W. W. COOKE,
Director Experiment Station.

G. G. BENEDICT,
Sec. U. V. M. State Agricultural College.

REPORT OF THE DIRECTOR.

The present report covers the work of the Station from January 1 to December 31, 1891, though a small amount of the chemical work used was not completed until a later date ; the financial report covers the year ending June 30, 1891.

PUBLICATIONS.

During the year four bulletins have been issued as follows :

March. No. 23. Analyses of Licensed Fertilizers.
May. No. 24. Potato Blight and Rot.
June. No. 25. The Bounty on Maple Sugar.
September. No. 26. Maple Sugar.

An Annual Report was also issued embracing the work of Station for the year ending December 31, 1890.

These bulletins were published in editions of eight thousand each, except No. 26, of which an extra edition of five thousand had to be published to supply the immediate demand, and later a third edition of four thousand copies. An abstract of these bulletins is given in this report. There are a few copies yet on hand of the former bulletins, that will be sent to those desiring as long as the supply lasts.

CHANGES IN STATION STAFF AND EQUIPMENT.

Few changes have taken place in the working force during the year. Mr. A. B. Cordley resigned to accept a position in the Agricultural Department at Washington, and Dr. F. A. Rich of Avon, N. Y., has been appointed Veterinarian to the Station.

Since the last report was published the buildings have been completed on the new farm, lately purchased adjoining the University grounds.

THE FARM.

The farm is admirably adapted for an experimental farm, comprising 80 acres, varying from heavy clay, through gravelly loam and clay loam to a sandy loam. Most of it is already in a high state of cultivation and the crops taken from it the past year have more than equalled expectations. The Trustees of the University have lately purchased 30 acres more to be used as a pasture.

THE BARN.

The barn is 48x105, with 22 foot posts, the floor of the cow stable being on a level with the sills and directly over a large cellar 45x80. The barn is balloon-framed, with eight-inch studding and eight-inch rafters. The first floor contains besides the cow stable, which can accommodate 35 head of stock, tool room 20x40, carriage room 23x25, horse stall and harness room 20x25, a carriage wash rack, a sheep fold and a model piggery, each 20x20. While just outside are three bull pens for the three different breeds of cattle kept. The floor above is the main barn floor and the hay mows on each side hold about 100 tons of hay. The grain bins hold over a carload. Over the sheepfold and piggery, and the tool and carriage rooms, are large seed and storage rooms. In the northeast corner of the barn reaching from cellar to roof are three great silos which will hold nearly 200 tons of ensilage, and which were filled to overflowing by the unexpectedly large yield of the past year. The walls of the silo are made tight by combining sheathing, air space, building paper and a second sheathing. The inside is well painted with asphalt and coal tar.

Two features of the barn call for particular attention, ventilation and watering. The ventilating shafts pass from manure cellar to cupola being 51 feet in perpendicular height. There are eighteen 8x20 inch shafts which open into the roof shafts and they have thus far given satisfaction. Each has openings on each floor and any part of the barn can be ventilated at will.

Watering the cattle is done by what is known as the Buckley watering device. Fastened on a post in front of the stanchion, between each two cows is an iron bucket holding a little over a gallon. They are all connected by an iron pipe with a water tank containing a ball valve. Any draft of water in any bucket lowers the level and water flows into the tank to restore it. The cattle have fresh water before them always, they like it much, sip a little every now and then, blow it around and its quantity is so small that it is continually being replaced by fresh water. Barn and creamery are wired for lighting by electricity.

THE CREAMERY.

On the first floor of the creamery building are separator room 24x22, churn room 24x14, ice house 25x14; and on the second floor, laboratory for milk testing 24x22, lecture room 24x14. At the other end of the same building are a carpenter shop 19x20, a potting room 19x20; and upstairs, botanical and horticultural laboratories, both 19x20. In the separator room are the separators, milk vat and a twelve-horse power Sturtevant horizontal engine run by a fifteen-horse power boiler in the cellar.

In the churn room are hand and power butter workers, box and barrel churns, cream vat, scales, Boyd's starter vats, etc., etc. In the milk laboratory is the full outfit for milk testing, including eight centrifugal Babcock testers, lactometers and glassware, while the lecture room is well equipped with charts, blackboards, etc.

The plumbing of the building is unique, as hot or cold water or steam

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over one thousand analyses and furnishing us with a mass of figures sufficiently large to give considerable weight to the deductions derived from them. These tests were made in the spring just as the cows were being turned out to pasture and were designed especially to test the effect on milk flow of the changes in the weather. The general results obtained in this work show that cows are quite variable, both in quantity and quality, the quality during a given time varying even more than the quantity, and that this applies not only to individual cows but to whole herds. The reason of these variations has not yet been determined, but is undoubtedly dependent on quite a number of causes. It was found by experiment that to get the average character of the milk it was not necessary to take a sample of each days milking,but that six or eight samples a month were just as good as thirty, and that by using preservatives in the milk, not more than four analyses at the most need be made per month. Only one clearly marked connection could be traced between weather and milk flow, and that is, as the weather becomes colder cows tend to give richer milk, and in warmer weather give thinner milk. This is probably a partial explanation of the fact long known, that the same cow when calving in October, gives on the average richer milk than if she calved in spring, and is one of the strong arguments in favor of winter dairying. Some surprising negative results were obtained in that there was nothing to indicate that storms or bad weather decreased the quantity or quality of milk. This is directly contrary to the belief of a good many, and quite contrary to the teachings of most dairy writers, and still the mass of testimony is so large that it cannot be lightly gainsaid. As in past years, it was found that the general effect of change from barn to pasture was an increase in both quantity and quality of milk.

The analyses of skimmilk and buttermilk, show that the practical creamer does do fairly good work, and a good deal better than that done in the best of private dairies.

Attention is also called to the wide variations in the analysis of butter from this creamery, which variations are probably no larger than occur in most creameries, but show how very variable is the character of the article called butter.

CORN ENSILAGE.

An extensive feeding test was made between corn ensilage and corn fodder from the same sources. The result as a whole showed that the feeding value of the two was but little different. They lose just about the same amount in dry matter during the processes of ensilaging and stooking, the corn fodder losing the larger amount of albuminoids and the ensilage the larger amount of starch and sugar. The corn ensilage produced on the whole 837 pounds more of milk, or 9 per cent, but the milk from the ensilage was not so rich as that from the corn fodder, so that the total increase of butter fat was but 16 pounds or 4 per cent. The cows had the same amount of grain and hay and were fed all they would eat of the ensilage or corn fodder. Under these conditions the ensilage lasted one-twentieth longer than the corn fodder or about one week longer on the winter's feeding.

It was noted that whenever the cows shrank in milk there was a decrease in the total amount of water taken into the system and every time there was a gain in milk there was an increase in water consumed and this held good whether they were eating ensilage or corn fodder. The shrinkages in milk and in water taken into the system are almost exactly proportional. This rule was found to hold good in experiments made at other stations.

CHEESE MAKING.

A series of experiments on making cheese from different qualities of milk may be summarized as follows :

The quality of milk has little effect on the amount of fat lost in the whey for each hundred pounds in the original whole milk, The amount of cheese made is not proportional to the amount of fat in the milk. The richer the milk the less cheese will be made for each pound of fat. Between 3 and 4 per cent, the market value of the cheese increases with an increase of fat in the whole milk.

In general terms milk containing 4 per cent of fat will make 10 2-3 pounds of cheese for each 100 pounds of milk. Milk containing 3 per cent of fat will make 9 pounds of cheese and milk containing 5 per cent of fat will make rather less than 12 pounds. The cheese from 4 per cent milk will sell on the market for about three quarters of a cent a pound more than that from 3 per cent milk and cheese made from 5 per cent milk will not sell for any more than that from 4 per cent. So that for cheese making purposes a hundred pounds of 3 per cent milk is worth a fourth less than a hundred pounds of 4 per cent milk and a hundred pounds of 5 per cent milk is worth an eighth more instead of a fourth more as it would be were we to judge entirely by the amount of fat present.

The mechanical losses in cheese making are shown to be rather less than those in butter making. The changes that occur during the ripening of cheese seem to be continuous losses of water and small losses of fat, probably from its oozing out through the rack, and slight losses in casein.

TESTING COWS.

For the testing of individual cows as to the amount of butter they will make in a week, a new method is proposed, namely, the keeping of milk in deep setting in ice-water, allowing several milkings to accumulate, then warming up the whole and running through a hand separator, separating only twice for the fourteen milkings. In this way it was found possible to carry into the butter 95 per cent of the fat in the original whole milk, making 119 pounds of butter containing 80 per cent of fat from each 100 pounds of fat in the original whole milk, thus equaling with small quantities of milk the best creamery practice.

FEEDING.

Sweet skim-milk and sour skim-milk were fed in comparison to pigs with a decided advantage in favor of the sour-milk. Heavy feeding of corn meal was tried as compared with moderate feeding. The heavy feeding produced a more rapid growth than moderate feeding but at a greater cost for each pound of growth. A summary of our experiments in feeding pigs shows that pig feeding can be made profitable wherever skim-milk serves as part of the ration. On the average 2.84 pounds dry matter has been required to produce one pound of gain in live weight. The food to produce a pound of live weight has cost on the average 4.19 cents and has sold for 5 cents a pound, a gain of 19 per cent over cost of feed, and this after counting skim-milk at 15 cents a hundred, when it can be bought at the creameries for 10 cents or less. There has been returned in the fertilizing value of the food just about two-thirds of its market cost, thus furnishing a large return for the time and labor.

ABSTRACTS OF BULLETINS.

BULLETINS No. 26 and 30.

MAPLE SUGAR.

The farmers of Vermont are large producers of maple sugar, and an investigation into the manner of handling necessary to secure the government bounty cannot fail to be of practical importance to them. Such an investigation has been in progress at this Station during the past six months and forms the basis for this bulletin. The conclusions arrived at are as follows :

1. An accurate thermometer is the sugar-maker's best guide in determining how to handle his syrup to make a sugar that will draw the bounty.

2. When sap begins to boil, its temperature is about 213° ; as it boils down and becomes thicker the temperature at which it boils rises until toward the end it may be 235°—240° or even as high as 245°.

3. If the syrup had nothing in it but sugar and water, at a temperature of 220° it would test 80° and at 243° it would test 90°. A degree means one per cent of sugar.

4. The syrup also contains mineral matter, malate of lime, ("nitre" or "sugar sand") burnt sugar, and toward the end of the season various materials resembling glucose, due to the starting of the buds and the beginning of the summer's growth of the tree.

5. These extra materials at the beginning of the season are about one-sixteenth the weight of the sugar, and increase until in some very poor and black "last run" they may amount to thirty pounds for every hundred pounds of actual sugar present.

6. Hence 100 pounds of a first-class syrup boiling at 228° instead of containing 80 pounds of sugar, contains about 75 pounds of sugar and enough of the other materials, 5 pounds, to make up the eighty pounds, the other 20 pounds being water.

7. Such a syrup will have to be heated to 231° and some more of the water driven off, before it will contain 80 per cent of actual sugar, and to 248° to contain 90 per cent sugar.

8. The more the impurities the higher the temperature to which the syrup will have to be heated.

9. To make a sugar testing 80° by the polariscope, first run syrup will have to be heated to 233°. The general run of good quality syrup through the most of the season will need to be heated to 235° and if it is a

little dark to 236°. Toward the latter part of the season the temperature will need to be raised to 238° and the same should be done at any time when a syrup gets scorched, or for any reason seems to be of poor quality. This is always on supposition that the syrup is stirred until it grains according to the ordinary custom in Vermont, before it is poured into the tubs or pails. If the malate of lime is not removed, these temperatures will need to be raised two degrees.

10. The last run cannot be made into a sugar testing 80°. This is always true after the buds start, and usually the case with the one or two runs next previous.

11. A sugar containing 90 per cent of pure sugar can be made only from the best of syrup in the first half of the season. The syrup to make it will have to be heated to 242°.

12. The syrup that will make 100 pounds of sugar testing 80° and drawing a bounty of $1.75. will make 88 pounds of sugar testing 90° and drawing a bounty of $1.76, a loss of 12 pounds of sugar to gain ONE CENT in bounty.

The 90° sugar will need to be sold at a cent a pound higher than the 80° to make up for the loss in weight. Hence :—Do not try to make a 90° sugar for the sake of getting the two cents a pound bounty, unless you have a special market that will pay you at least a cent a pound extra for the hard sugar.

13. A syrup boiling at 219° has a specific gravity of 1.325 and weighs just 11 pounds to the gallon. This will not granulate under ordinary conditions, but at 220° crystals of sugar will begin to form.

14. A syrup weighing 11 pounds to the gallon will, if of good quality, make 8¾ pounds of sugar, testing 80° and drawing a bounty of 15 cents, or 7¾ pounds of sugar testing 90° and drawing the same bounty.

CONDITIONS OF THE BOUNTY.

The particular points to be noticed are that the government will pay a bounty of two cents a pound for all sugar testing ninety degrees or over by the polariscope, and a bounty of one and three-fourths cents per pound for sugar testing from eighty to ninety degrees. A degree means one per cent of pure sugar.

In order that the farmer get the advantages of this bounty he must have taken out a license before July first of the present year, and he must make at least 500 pounds of sugar which tests eighty degrees or over by the polariscope. It makes no difference whether the sugar is sold or consumed at home provided 500 pounds is made which tests over 80°. A bounty will not be paid for *syrup* in any form, for any sugar made previous to July 1, 1891, for sugar made after July 1, from syrup made before that date, nor for sugar testing less than 80° by the polariscope.

CHARACTER OF MAPLE SAP.

The sap from which the maple sugar is obtained is composed of water, sugar, various mineral matters, such as lime, potash, magnesia, iron, etc., and some organic matters in the shape of vegetable acids. These in a state of purity are all colorless. The sugar of the maple is exactly the same in composition as cane sugar—the ordinary white sugar of commerce—and it is possible by exercising sufficient care in evaporating, by filtering and by decolorizing, to obtain a white maple sugar that cannot be distinguished by any test of the eye, the taste, or the chemist from ordinary white cane sugar. The brown color of the ordinary maple sugar is due to the changes that take place during the boiling down of the sap. In this process the water is driven off and more or less of the sugar is changed by the heat into other forms called glucoses, at the same time becoming browned. This change takes place even when there is no sign or smell of burning and when the syrup does not stick to the pan. It of course takes place much more readily when the syrup is allowed to burn. Unless special care is taken in handling the sap, outside impurities get in, leaves, twigs, dust and especially drippings from the bark and branches of the trees; these all contain coloring matter and help to darken the syrup and resulting sugar.

The sap is purest, that is contains the least amount of matter not sugar, when it first begins to run in the spring; the proportions change but slowly during the first few weeks, but during the latter part of the season the sugar begins to break up from the action of natural laws and becomes changed into very much the same material as is made when it is burned in boiling down. The sugar in the sap is nature's food for the growth of the tree, but this sugar cannot be used so long as it remains in the form of sugar. Before the buds and leaves can make use of it, it must be changed into glucoses, and this is the change that begins to take place as soon as there is the least sign of growth in the spring. The change goes on rapidly and by the time the swelling of the buds becomes visible to the eye a quarter or more of the sugar has become changed. It follows, therefore, that all maple syrups will contain some glucoses. The amount in the best of syrups is about one per cent, and this amount increases until in the latter part of the season it becomes very large. We have found as high as 13 per cent in a sugar which seemed to be of a pretty fair quality, while in some of the dark black sugars made from the last runs it is probable that nearly one-third of their weight is not real sugar.

THE POLARISCOPE.

The law of Congress says that the bounty shall .be paid on the amount of sugar as shown by the polariscope. These other materials spoken of, the mineral matter, vegetable acids, glucose, etc., are not shown by the polariscope, which is an instrument for determining the amount of actual pure sugar there is contained in the substance. Hence, the larger amount of these impurities there is in the given sample of sugar the smaller the amount of pure sugar present. So many questions have been asked us in regard to the polariscope that a short description will be given : If a ray of light is passed through a tube filled with pure water it will go directly through it, being turned by the water neither to the right nor left. If, however, the tube is filled with a solution of sugar, the ray of light will be turned to one side, and the stronger the solution the more the light will be turned. The polariscope is an instrument for measuring the amount of sugar there is in a given solution by the amount that the light is turned in passing through this solution. The analysis is made as follows :

A known weight of sugar is dissolved in a known weight of water. Certain chemicals are added to get rid of the coloring matter and make a clear solution. A tube of known length is filled with this solution and the plate of the instrument is moved until the ray of light passes directly through. There is a graduated scale attached to the instrument so adjusted that from the amount the plate had to be moved there can be read at once the per cent of pure sugar there was contained in the original material. The instruments are quite expensive, costing from $150 to $250 ; hence they would be too expensive for the farmer to purchase if he desired, and there is no reason nor necessity for his testing the sugar himself, since that will be done by the government without expense to the farmer.

TESTING SYRUP.

If the sap contained nothing but the sugar, it would be a simple matter to tell exactly how to make a sugar that would test 80°, or if the impurities present in addition to the sugar were constant it would still be a comparatively simple matter, but the amount of these impurities is variable from one sugar orchard to another and change very largely from the beginning of the season to the end, requiring different treatment for different times and places, thus increasing largely the difficulties of the case. Since it is not possible for each farmer to have a polariscope and make his own tests to know when his sugar contains 80 per cent of pure sugar, it is necessary to find some other way by which he can arrive at an approximate idea of the amount of sugar present. Two ways have been suggested for determinining this point. One by weight and the other by temperature.

TESTING WITH THE HYDROMETER.

All sugar makers know that as the sap is boiled down it becomes heavier and heavier, that is a gallon of it weighs more and more, or in technical language its specific gravity becomes greater. This specific gravity is shown by an instrument called the hydrometer or sacchrometer, which acts on the same principal as the lactometer with which most farmers are familiar. The hydrometer is simply a glass bulb, weighted at the bottom so that it will float upright in the syrup and having a long graduated glass tube at the upper end. When this instrument is put in pure water it sinks nearly to the top of the glass tube to what is marked as the zero point. The heavier the syrup the less this bulb will sink, and the heaviness or strength of the syrup can be told from the amount that the bulb sinks If the syrup were all sugar without any impurities it would be possible to tell exactly from the bulb how much sugar there was in the syrup, but the other materials present act just as the sugar does to make the solution heavier, so that the amount of the pure sugar present cannot be told directly from the bulb unless we also know the amount of impurities present. Enough experiments have been made at the Station this spring, so that we can give an approximate idea of the amount of sugar in the solution from the reading of the bulb in various syrups from the first run, middle and last runs. The figures for a good quality of early made syrups are given on page 57 of this bulletin, the first three columns being the readings of the three kinds of hydrometers in use, and the fourth line the amount of sugar present. The hydrometer is not of much value above 224°, since the syrup is then too viscid to admit of accurate determination by ordinary hydrometers. The specific gravities given in this bulletin were determined by the Westphal balance.

TESTING WITH THE THERMOMETER.

The long series of experiments carried out at this Station lead us to believe that the sugar maker can most safely and surely judge the quality of his product by the intelligent use of an ACCURATE thermometer. Too much stress cannot be laid on the word accurate thermometer. The ordinary cheap tin thermometers are very apt to be incorrect and misleading. It will prove poor economy to use an inferior instrument. Good thermometers are on the market at reasonable prices, the accuracy of which are guaranteed. Such thermometers are for sale by the Vermont Farm Machine Co., Bellows Falls, Vt., by the Vermont Maple Sugar Exchange, Brattleboro, Vt., and by L. R. Tabor, Westford, Vt. The Station will test free of charge the accuracy of any thermometer sent for examination.

Pure water boils at 212° F. If sugar or any of the materials that are ordinarily found in syrup is added to this water, the temperature at which it boils is increased, and the more sugar there is present the higher the boiling temperature, until in strongest solutions of pure sugar it rises to about 260°. It is possible then from the temperature at which the syrup is boiling to tell approximately the amount of sugar present. If the syrup contained nothing but the pure sugar it would be possible to tell exactly. For instance, we know that a pure syrup boiling at 221° contains 70 per cent of sugar, and boiling at 231° contains 80 per cent, etc., but as was just said in regard to determining sugar by specific gravity, the impurities present act on the the temperature very much the same way as the sugar, so that when a syrup is boiling at, say 221°, we can say there is about 70 pounds of substance there which may be sugar, or it may be partly sugar and partly impurity.

METHODS OF ANALYSIS.

When it became known that the bounty law had passed, the Station was flooded with inquiries concerning the meaning of the law, the use of the polarscope and especially how hard the sugar had to be made in order that it should test 80° or 90°. It was found at once that there were no figures in existence on this latter point. A great deal of work had been done on the sugar-cane, sorghum and beet-sugar, but nobody had ever made any experiments with regard to the way maple syrup would have to be handled to make a sugar testing 80° by the polariscope. For the past six months this Station has spent a great deal of time in work on this subject.

In the course of the work the Station has handled a great many gallons of syrup from nineteen different sources, in some cases in the sugar bush or at the sugar maker's home, and in others at the Station building, and has made over five hundred analyses.

In general the work was done as follows: From five to six gallons of syrup were sugared off on a stove, samples for exhibition and analysis, both stirred and unstirred, being taken from the boiling syrup as it arrived at various temperatures, usually from 232° to 238°. Weights, losses on evaporation, losses from stirring and granulation, specific gravities, crystallization and boiling points, etc., were also taken at various times. Except in the matter of taking out samples from the boiling syrup the usual Vermont method of sugaring off was carried out in every case, and there is no reason to believe that in actual work the sugar maker would get any less sugar than we.

CHARACTER OF VERMONT MAPLE SYRUP.

The principal thing to be determined in our work here was the amount of impurity that is present or may be present in syrup at different places and different times in the season. We determined this in a great many samples. Sugar bushes were visited in different parts of the State during the sugar season last spring, the samples taken for each degree of increase in temperature from the time the syrup began to get thick until it was taken off from the fire. These samples were brought to the Station and tested for the amount of pure sugar present. This work was kept up through the whole of the sugar season so that we obtained samples of the early runs, the middle of the season and the last run. In addition to these we obtained quite a number of samples of syrup in quantity and sugared off at the Station, giving us altogether a series of syrups which we think will include the extremes of goodness and badness as they occur in the State.

A good quality of syrup contains in 100 pounds about 4 pounds of solid matter, not sugar, and a good sugar about 6 pounds, i. e. the foreign matter is about one-fifteenth as much as the pure sugar present. Hence, sap contains in 100 pounds from 3 to 5 pounds of sugar and about one-fourth pound of other solid materials. As the sap boils down, little change takes place, except the loss of water, provided the syrup is good and is properly handled, but a poor syrup, or a good syrup poorly treated, will lose sugar as well as water, through the burning or "inverting" of the sugar.

At a temperature of 230°–234° a moist mushy "tub-sugar" will be made which will drain a good deal of molasses, while at 240° and upwards, a very hard, crystalline "cake-sugar" will be obtained. The former will seldom contain eighty and the latter will sometimes contain ninety per cent of sugar.

STIRRING OR GRANULATING SUGAR.

In the Vermont methods of making sugar when the syrup is supposed to be done enough it is raised from the stove and stirred until the grains of sugar begin to show, usually stirred until it is quite thoroughly grained. During this process the temperature is all the time falling, but at the same time steam is passing off and the syrup is becoming concentrated and therefore contains a higher per cent of sugar. We made a great many determinations how much increase in percent of sugar there was during this process of stirring, but of course no exact figures could be obtained because the stirring at different times was under different conditions and for different lengths of time. If the sugar is to be caked or granulated, of course the stirring is longer and the consequent loss of water and increase of sugar is greater.

A series of tests including analyses and weight before and after stirring and granulating indicate that the shrinkage in weight on stirring is practically all water. This is what might be expected for the heat being removed all danger of caramellizing is over. The amount of shrinkage varies according to the amounts stirred, but on a working scale probably amounts to not less than one-fortieth in stirring and one-twenty-fifth in granulating. These shrinkages of course correspondingly increase the sugar percentage over the unstirred material.

The average of 2° of sugar gained in stirring or granulating corresponds to about 2° of temperature, i. e. if a sugar tests 80° at 237° unstirred it will test 80° at about 235° after stirring.

Hence it will be seen that if a first class syrup is stirred, it will make a sugar testing 80° when it is taken off at a temperature of 231°, that a medium syrup reaches the same point at 234° and that a poor syrup never can be heated high enough to reach 80°. It will also be seen that the 90° point would be reached in the first class syrup at 242° and that nothing but the best of syrup is pure enough to make a sugar that will test 90°.

TEMPERATURE TO BE EMPLOYED.

From these figures we are enabled to give the following directions to sugar makers:

To make a sugar testing 80°, a first run syrup should be treated to 233°. The general run of good quality syrup through the most of the season will need to be heated to 235°, and if it is a little dark to 236°. Toward the latter part of the season, the temperature will need to be raised to 238°, and the same should be done at any time when the syrup gets scorched or for any reason seems to be of poor quality. These temperatures are on supposition that the syrup is stirred until it grains, according to the ordinary custom in Vermont, before it is poured into the tubs or pails. If the malate of lime is not removed, these temperatures will need to be raised about two degrees. The temperature of 233° mentioned for early run syrup, while it will make a sugar testing 80° and subject to the bounty, will leave the sugar more soft than is desirable for sale on the general market, and it will probably be more satisfactory to heat it to 235°.

These directions will in most cases give a sugar that is really a degree or two above 80°, but it is thought best to err for safety on that side.

DRAINED SUGAR.

The statement has already been made that the last runs of syrup will not make a sugar that will test 80°. By boiling such a syrup down to about 235°, stirring it, putting into the tubs, and after a few days, turning on the side and letting the molasses drain out, it is possible to get a good quality of sugar that will test a good deal more than 80°. One sample that we treated in this way tested before draining 67°, while the molasses had about 50 per cent of sugar.

NITRE.

The name of "nitre" or "sugar sand" is applied by Vermont farmers to the malate of lime in maple syrup. It is a combination of malic acid and lime and is found in all syrup, though in quite variable quantities.

Most sugar makers boil down syrup until it weighs nearly 11 pounds to the gallon and then let it cool and stand for the nitre to settle, the syrup being either poured off or strained through thick cloths to free it from the nitre. In all the figures and temperatures given above it is supposed that the nitre has been taken out. If the syrup is done down nearly to sugar as is sometimes done leaving the nitre in, it will be necessary to raise this temperature 2° in order to get a sugar testing 80° by the polariscope.

WILL ORDINARY SUGAR GET THE BOUNTY.

A large number of samples of sugar were sent to the Station by various makers last spring, being in most cases the ordinary sugar as they were in the habit of making it to put on the market. Nearly all of these samples test over 80° and a few of them went over 90°, while one tested as high as 96°, this last being a very fine and dry white granulated sugar that one would hardly believe could be the pure product of the maple tree. From these analyses it seems probable that most of the sugar made in the State during the early and middle part of the season will test 80° and draw a bounty of 1¾ cents per pound. All good sugar as ordinarily made during the first part of the season will deserve a bounty.

IS THE HIGHEST BOUNTY DESIRABLE.

One question often asked is, shall we try to get the 2 cents a pound bounty by making sugar that will test 90°? A hundred pounds of sugar testing 80° will make 88 pounds of sugar testing 90°, provided it is pure enough so that it can ever be boiled down to that extent. The 100 pounds of 80° sugar will draw a bounty of $1.75 and the 88 pounds of 90° sugar will draw a bounty of $1.76, or a loss of *12 pounds of sugar for the sake of gaining 1 cent in bounty.* It will be necessary to sell the 90° sugar at about one cent a pound more than the 80° in order to make up for the loss in weight. From these figures it is evident that no one can afford to try to get the 2 cent bounty unless they are sure that they have a special market that will pay them enough extra for the hard sugar to make up for the great decrease in quantity.

SYRUP-MAKING.

The particular point in making syrup is to get it as thick as possible without having it granulate on standing. The ordinary rule of the maker is to make syrup that shall weigh 11 pounds to the gallon, and we have found by experiment that this custom is exactly right, and that the temperature corresponding to this weight is 219°. That is, if the syrup is taken off from the fire as soon as it shows a temperature of 219° it will weigh exactly 11 pounds to the gallon and will not grain on standing. This is, however, the extreme limit; if the temperature is allowed to get a single degree higher the syrup will granulate. In practice not much of the syrup that is on the market is quite up to this point, most of it being taken off just before it reaches 219°, and large quantities were on the market last spring which boiled at 216°, or even less. It becomes a matter of some commercial value to know the relative amount of sugar in syrups of these different qualities. That is, if a dealer expects to pay a certain amount for syrup weighing a certain amount per gallon, how much less should he pay for syrup weighing less than 11 pounds, and how much for that weighing more than that?

Rules for this have been laid down for cane-sugar syrups*, but the figures have never been before calculated for maple syrups.

Water has a specific gravity of 1.000. A gallon of it weighs almost exactly eight and a third pounds. Maple syrups are heavier than this and grow heavier as they become more concentrated, and as the sugar percentage increases. There is quite a close relation between the boiling point and the specific gravity or weight of the syrup. In the course of several sugarings off the weight of the syrup at each degree rise in temperature was taken and they were found to be closely uniform, that is to say that at a given boiling temperature all syrups have about the same weight per gallon. The following table shows average specific gravities and weights per gallon for the various temperatures from 213°:

Temperature of Boiling Point.	Degrees Baumé Hydrometer.	Specific Gravity.	Degrees Brix Hydrometer.	Approximate Per cent or Degrees of Pure Sugar.	Weight Per Gallon. lbs.	Relative Value Per Gallon.
215°	25.0	1.205	44.9	41	10.4	67
216	29.3	1.250	53.1	50	10.4	87
217	32.0	1.279	58.1	54	10,7	90
218	33 9	1.301	61.9	58	10.8	95
219	35.5	1.319	64.9	61	11.0	100
220	36.7	1.333	67.1	63	11.1	103
221	37.8	1.347	69.4	66	11.2	108
222	39.0	1.362	71.8	68	11.4	111
223	39.8	1.372	73.3	70	11.4	115
224	40.6	1.382	74.9	71	11.5	116
225	41.3	1.391	76.2	72	11.6	118
226	42.0	1.400	77.7	73	11.7	120
227	42.6	1.408	78.8	74	11.7	121
228	43.2	1.416	80.0	75	11.8	123
229	43.8	1.424	81.2	76	11.9	124
230	44.3	1.431	82.2	77	11.9	126
231	44,8	1.439	83.3	78	12.0	128
232	45.2	1.445	84.3	79	12.0	129
233	45.6	1.451	85.2	80	12.1	131
234	46.0	1.457	86.0	81	12.1	133
235	46.4	1.463	86.9	82	15.2	134
236	46.8	1.469	87.7	83	12.2	136
237	47.2	1.475	88.6	84	12.3	138
238	47.6	1.481	89.4	85	12.3	139

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*The rules for cane-sugar syrups will not apply to maple syrups, both on account of the fact that the maple syrup contains some impurities, and also because these impurities have a different effect from the sugar on the boiling temperature. The effect of the sugar and the impurities on the specific gravity seems to be the same; thus a syrup containing 90 per cent of sugar and no impurity will have a specific gravity of 1.485, and one containing 85 per cent sugar and 5 per cent impurity will have the same specific gravity, but while the latter will boil at 238°, the former will not boil until it reaches 253°.

Degrees Baumé Hydrometer.	Specific Gravity.	Degrees Brix Hydrometer	Approximate Per Cent of Pure Sugar.	Temperature of Boiling Point.	Weight Per Gallon. lbs.	Relative Value Per Gallon.
25	1.205	44.9	41	215.0	10.0	68
26	1.215	46.8	43	215.1	10.1	72
27	1.226	48.7	45	215.3	10.2	75
28	1.236	50.5	47	215.6	10.3	78
29	1.246	52.4	49	215.9	10.4	82
30	1.257	54.3	51	216.2	10.5	85
31	1.268	56.2	53	216.6	10.6	88
32	1.279	58.1	54	217.0	10.7	90
33	1.290	60.0	56	217.4	10.7	93
34	1.302	62.0	58	218.1	10.8	97
35	1.313	63.9	60	218.6	10.9	100
36	1.325	65.8	62	219.5	11.0	103
37	1.337	67.8	64	220.3	11.1	107
38	1.350	69.8	66	221.2	11.2	110
39	1.362	71.8	68	222.0	11.3	113
40	1.374	73.7	70	223.2	11.4	117
41	1.387	75.7	72	224.5	11.6	120
42	1.400	77.7	74	226.0	11.7	123
43	1.415	79.8	75	227.8	11.8	125
44	1.428	81.8	77	229.7	11.9	128
45	1.442	83.9	79	231.8	12.0	132
46	1.457	86.0	81	234.0	12.1	135
47	1.471	88.1	83	236.3	12.3	138
48	1.486	90.2	85	238.7	12.4	142

The per cents of sugar given above are calculated for a fairly good syrup. The relative value in the last column is based on these per cents, but will be nearly the same for all except the poorest of syrups. The relative value is made use of as follows: A weight of 11 pounds per gallon, and 35° Baumé is taken as the standard. Dividing the weight of the syrup by 11 gives the number of standard gallons. Multiplying the price that is to be paid for 11 pound syrup by the relative value figure and dividing by 100 gives the price to be paid per standard gallon.

Example: If 75 cents a gallon is to be paid for 11 pound syrup, how much should be paid for 671 pounds of syrup testing 31° by the Baumé hydrometer.

$671 \div 11 = 61$ standard gallons.
$75 \times 88 \div 100 = 66$ cents per gallon.
$61 \times 66 = \$41.26$, price to be paid.

SYRUP OR SUGAR.

In conversing with farmers one question that is frequently asked is this : " Can we afford to make sugar and get a bounty rather than sell our product in the form of syrup." To determine this point we made a number of experiments to find out the relation existing between syrup and sugar, that is how much sugar could be made from a gallon of syrup.

As found upon the market the different grades of syrup loose weight unevenly on evaporation as evinced by the following : Two syrups boiling at 214°, specific gravity 1.225, weight 10¼ pounds to the gallon, shrank 40 and 42 per cent in boiling to 240°. One syrup boiling at 215°, specific gravity 1.255, weight 10½ pounds to the gallon, shrank 25 per cent in boiling to 238°. Two syrups boiling at 217.5° to 218°, specific gravity 1.296, weight 10 4-5 pounds to the gallon, shrank 24 and 22 per cent in boiling to 246°. Two syrups boiling at 219.5 specific gravity 1.307 weight 11 pounds to the gallon, shrank 23 per cent in boiling to 242°. This simply means that the poorly made low boiling syrups have more water to lose on evaporation than the better class. This difference disappears when the loss on evaporation is determined on all the syrups from one boiling point. This shrinkage is almost all water. From 220° to 232° there is caramellizing or destruction and some inversion of the sugar ; from 232° to 238° little or none ; from 238° upwards the loss of true sugar is quite rapid.

In boiling down the loss in *weight* from degree to degree is uneven being rapid at first and slower later on. Thermometer and scales work inversely. The scales drop rapidly at first and slowly later, the mercury rises slowly at first and rapidly later. There is then no direct relation between loss in weight and the degree of the thermometer. Generally, however, from 231° upwards the loss between each degree is slight and quite uniform, and from 233° upwards invariably slight and almost uniform. Below 231° it is more uneven, increasingly so in the lower degrees.

Weight of sugar obtained from 100 pounds of syrup weighing 11 pounds to the gallon, when sugared off at different temperatures :

Temperature of sugaring off.	Average weight. lbs.	Highest weight. lbs.	Lowest weight. lbs.
232°	82.7	82.	83.3
233	81.9	80.5	82.8
234	81.2	80.	81.9
235	80.8	79.5	81.6
236	80.5	79.5	81.1
237	80.	79.	80.9
238	79.5	78.5	80.7
239	79.2	78.4	80.3
240	78.7	78.2	79.7
241	78.5	77.9	79.3
242	78.1	77.4	78.9

It will be seen that a gallon of standard syrup weighing 11 pounds will make 8¾ pounds of sugar testing 80°, on supposition that the syrup is of the best quality, and will draw a bounty of 15 cents. It will also make 7¾ pounds of sugar testing 90° and drawing the same amount of bounty. From these figures it is possible for any one knowing the price he can obtain for syrup and for sugar to determine which will be his best course financially. Thus, if he can get 75 cents a gallon for 11 pound syrup and has to pay 10 cents for the can, the syrup would net him 65 cents a gallon. This made into sugar would give him a bounty of 15 cents so that he would have to sell the sugar for 50 cents or about 6 cents a pound in addition to the value of the package, in order that the sugar should net him as much as the syrup.

If the syrup is not of good enough quality to make a sugar that will draw a bounty, it will still make the 8¾ pounds of sugar but will have to be sold at a higher price to equal the price of the syrup. Thus, in the case given about it would have to be sold for 65 cents, or about 7½ cents a pound plus the cost of the package, to be equivalent to the value of the syrup at 75 cents a gallon.

REGULATIONS.

The following regulations made by the Treasury department show the methods that have been used this Spring (1892 :)

Collectors will, upon request, furnish blank forms to sugar producers, and instruct them in the steps necessary to be taken for obtaining bounty.

They will sub-divide the districts to meet the requirements of applicants for bounty, and station a sugar weigher at some convenient point in each sub-division.

They will provide weighers with blank returns, triers or sampling instruments, sample boxes, stencil plates, blank books, and, when necessary, with scales.

They will examine producers' applications and daily records, weighers' returns and chemists' classifications, find the amount due the purchaser, certify the same to the Commissioner of Internal Revenue, and, when received, transmit checks in payment of bounty to the purchasers entitled thereto.

Weighers will see that licensed applicants for bounty make returns at the beginning of the sugar season of all sugar and syrup on hand.

They will, during the sugar season, weigh at their stations, all sugar presented to them, in packages of ten pounds or more, by licensed applicants, and mark each package weighed with the weigher's name, gross weight, tare and net weight.

They will, at the close of the sugar season, beginning on the date designated by the collector, visit each factory in their respective subdivisions, and weigh, mark and record in like manner all the sugar left on hand.

They will make as many sub-divisions of the different lots presented for weighing as there are different kinds of grades in the lot, and draw one sample of three ounces from each sub-division, the sample to be so drawn as to fairly represent the lot sub-division from which it is taken.

The samples will be put in the boxes provided, covered immediately, and the blank label on the box filled out.

They will receive the producer's record on his premises, at the close of the season, take acknowledgment of the affidavit thereon, and see that it is in due form.

They will receive no fee for taking such acknowledgment, or administering oaths.

They will take care that no fraudulent claims are presented against the government.

Bounty will be paid only to those licensed applicants producing 500 pounds or more, testing at least 80 per cent of pure sugar.

The application must be in the hands of the officers before the first day of July. It will not do to mail it on the 30th of June expecting it to be received.

They must put all sugar upon which bounty is claimed in packages of 10 pounds or more.

They must number the packages serially, beginning with No. 1.

They must leave covers of packages unfastened until samples have been drawn.

They must mark each package with the producer's name.

They must mark each package before it is filled, with its weight, to be deducted as tare.

They must not claim bounty on adulterated sugar.

They must not claim bounty on sugar made prior to July 1, 1891.

Great care was taken at the laboratory to make correct analyses and no sample was passed as below 80° until it had been proved so by two analyses.

In the matter of sugar inspection and classification for bounty, the regulations of the Internal Revenue Department have favored the producer to the utmost extent possible under the law. Weighers were instructed to take a sample for each grade of sugar, so that if one failed to pass bounty, another might fare better. The style of sample package and the time necessarily elapsing between sampling and analysis favored "drying out" of the sugar and a higher analysis. Indeed, in the same cases where a single sample of extra large lots was taken that failed to reach 80°, a revenue inspector was sent from Montpelier to divide the lot, and re-sample in several samples in the hope that *some* of the sugar might go above 80°. In other words, *the government spent money to re-sample these lots in order that it might pay bounty on a part of it.*

THE MAPLE SUGAR INDUSTRY OF VERMONT.

According to the last census, the product of Vermont during the spring of 1889 was 14,123,921 pounds of maple sugar valued at $1,081,899, an average of 7 7-10 cents per pound; and 218,252 gallons of maple syrup valued at $166,957, an average of 76½ cents per gallon.

Considering one gallon of syrup to be equivalent to eight pounds of sugar, gives a total production of 15,869,937 pounds with a value of one and a quarter million dollars. The total number of sugar producers in the State was 14,337 of whom 10,099 produced 500 pounds or upward.

THE BOUNTY IN 1892.

Through the kindness of Hon. J. E. French, Collector of Internal Revenue for this District, the Station has had access to the records of the laboratory at Montpelier where the sugar analyses have been made and we are thus able to present the results, several months in advance of their publication by the government. The records are complete for about nine-tenths of the season and afford a sufficient basis for estimating the remainder.

In the summer of 1891 this Station issued a bulletin urging the sugar makers of the State to take out licenses for the sugar bounty. As near as can be ascertained, somewhat over a thousand persons who otherwise would not have dove so, were thus induced to get licenses and these thousand will as a result this spring be paid by the government something over $13,000 in sugar bounties.

In addition to this the Station sent to each sugar producer who had taken out a license, a circular calling for answers to the following questions: Number of trees tapped this spring; total pounds of sugar made; total gallons of syrup made; pounds of sugar sold to date; average price received per pound; gallons of syrup sold to date; price per pound at which rest of sugar could be sold now; price per gallon at which rest of syrup could be sold now; was your sugar sampled for the bounty; what part of an average crop of sugar did you have this year? Answers were received from 1084 persons and so large a number must give a fairly correct basis for estimating the maple sugar crop this year.

From the returns at Montpelier, it appears that 2,328,846 pounds of sugar were weighed and sampled this year for the bounty, of which 82,237 pounds or 3½ per cent tested 90° or over and is entitled to a bounty of two cents a pound; 1,939,339 pounds, or 83¼ per cent tested from 80° to 90° and is entitled to a bounty of 1¾ cents a pound, while 307,270 pounds tested under 80° and will get no bounty. In general terms **seven-eights** of the sugar tested will get the bounty. The law requires that at least 500 pounds testing 80° or over shall be produced to get the bounty. In the total quantities given above are included 522 pounds testing 90° or over and 27,306 pounds testing 80° to 90° that were in quanties of less than 500 pounds per person and hence lose the bounty. So that there remains 81,715 pounds at 2 cents per pound equals $1,634.30, and 1,912,033 pounds at 1¾ cents per pound equals $33,460.58, a total bounty for Vermont of **$35,094.88.**

According to the last census there were 10,099 persons in the State that in 1889 made 500 pounds or over of sugar. The treasury officials had expected that at least one-half of these would apply for the bounty, but as a fact only 2609 took out license papers, thus only a little more than one-fourth of those who could get the bounty took the first steps necessary to obtain it. Many of these did nothing further so that only 1918 actually had sugar weighed and tried to get the bounty.

The 691 who took out licenses but did not present any sugar to be weighed, had various reasons ; some did not tap their orchards this spring some did not make 500 pounds ; some made syrup instead of sugar ; quite a number were misled by the warm spell that occurred in the middle of the sugar season, into thinking that sugaring was over, and, as they had not made 500 pounds at that time, sold what they had without having it weighed. These 691 can be divided into 276 persons, or 40 per cent, who did not make 500 pounds ; 131, or 19 per cent, made syrup instead of sugar; 90, or 13 per cent, had various reasons, including those who did not tap their orchards ; and the remainder, 194, or 32 per cent, made over 500 pounds, but did not try for the bounty for reasons unknown to the Station. Those who were misled by the season are included under this latter head.

Of the 1918 who tried to get the bounty, 1671 succeeded and 247 failed; these latter being divided into 68 who failed because they made less than 500 pounds, and 179 because their sugar did not test 80°. The 1617 who obtained the bounty received on the average $21.70.

According to the census of 1890, there were in 1889, 4,238 sugar makers in Vermont who made less than 500 pounds of sugar apiece. If we estimate that these made on the average 350 pounds each, there remains 12,640,621 pounds made by the other 10,099 sugar makers, an average of 1250 pounds each. It is fair to presume that practically all of the 2,600 persons who took out bounty papers belonged among the ten thousand who made over 500 pounds ; then if this had been an average year they would have made at least 3,150,000 pounds of sugar, and the 1918 who did have their sugar weighed would have made 2,390,000. We find as a fact that they did make just about that amount and still considered the yield only a 60 per cent of a crop, which shows that those who tried for the bounty were confined more particularly to the largest producers who in favorable years make 2,000 pounds or over of sugar. Testing the same thing in another way, these 1,900 produced this year 2,328,000 pounds of sugar, and calling this 60 per cent of a season they would in an average year produce 3,880,000 pounds, or 2,020 pounds apiece.

THE PRESENT SUGAR SEASON.

The returns from 1084 persons, showed that they had made 1,368,000 pounds of sugar and 35,000 gallons of syrup from 870,000 trees. If a gallon of syrup is considered equivalent to 8 pounds of sugar, then the total product would equal 1,634,000 pounds of sugar, or 1⅞ pounds per tree. If these sugar makers are correct in their belief that the product this year was 6-10 of an average crop, then the average crop of Vermont is 3 1-10 pounds of sugar per tree.

As showing how rapidly the maple sugar crop gets into the market, it may be of interest to note that at the time our record closes, May 28, fifty-six per cent of the sugar made had already been sold, and since much sugar is used on the farm it probably represented fully three-fourths of all that would be sold. Over 60 per cent of the syrup made had been sold at that date.

RELATIVE PROFIT OF SUGAR AND SYRUP.

According to the census of 1890, the average value of the sugar produced in 1889 was seven and seven-tenths cents a pound, and of the syrup seventy-six and a half cents a gallon. According to exact figures a gallon of good syrup weighing just eleven pounds will make 8¾ pounds of sugar testing 80°. As most farmers make sugar above 80°, it is probable that the ordinary rule of eight pounds of sugar to the gallon of syrup is very close to average practice. Eight pounds of sugar at seven and seven-tenths cents a pound is 61.6 cents, and adding the bounty of 14 cents gives 75.6 cents, whereas the average selling price of the syrup was 76.5 a difference of less than a cent a gallon. It can be said then, that at the relative prices of sugar and syrup, the spring of 1889, it made no difference to the farmer on the average whether he made syrup and lost the bounty or made sugar and obtained it. As, however, most farmers must make sugar, rather than syrup, to such the bounty would be a benefit.

The replies received this spring indicated that much the same state of affairs exists now. The average of over a thousand sugar bushes, representing a total product of 1,370,000 pounds of sugar and 33,000 gallons of syrup, gives a selling price for the sugar sold previous to June 1, of 7.56 cents a pound and for syrup, 75 cents a gallon. The average prices current in the markets June 1, were 6⅔ cents for sugar and 70 cents for syrup. At these prices, syrup without the bounty would be worth 2 to 3 cents a gallon more than the same syrup made into sugar and drawing the bounty.

On the average, then, those who have made syrup for the general market have fared better than those who made sugar and drew the bounty.

It is evident from these figures that the reduction of the price of cane sugar has had but little effect *this season* on the price of maple sugar, the average price being but a half cent a pound lower than in 1889, while cane sugar has dropped more than two cents a pound. The average price of syrup this year is but 3 cents a gallon lower than in 1889. It is probable that the smallness of the crop has had considerable influence in keeping up the prices of both sugar and syrup.

Counting the prices on the average this year as 7 2-10 cents per pound for sugar and 72 cents a gallon for syrup and the crop 60 per cent of that of 1889, the State will get $46,955.00 less for the crop this year than at 1889 prices, and if this reduction in price is due, as it undoubtedly is to free sugar, then Vermont has lost $46,955 and gained $34,622, a net loss of only $12,000 and a gain of several hundred thousand dollars on the cost of granulated sugar.

Abstract of Bulletin No. 23.

ANALYSES OF LICENSED FERTILIZERS.*

Station Number.	BRAND.	NITROGEN.			PHOSPHORIC ACID.											POTASH.		
					Soluble.		Revrt'd.		Ins'l'ble.		Available.		Total.					
		Found.	Guaranteed.	Valuation at Station Prices.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Valuation at Station Prices.	Found.	Guaranteed.	Valuation at Station Prices.
4101	Williams & Clark Co. Pot. Phos.	2.95	2.47	$ 9.15	4.86	6	2.03	1.	2.07	1	6.89	6	8.96	7.	$11.65	5.51	5.	$4.95
4102	Williams& Clark Co. Am.Bo.Sup	2.70	2.47	8.37	6.55	7	1.90	2.	1.97	1	8.52	9	10.42	10.	14.12	2.69	2.	2.42
4103	Quinnipiac Potato Manure	2.76	2.47	8.50	4.78	4	1.84	2.	2.11	1	6.62	6	8.73	7.	11.25	5.11	3.	4.60
4104	Quinnipiac Phosphate	2.84	2.47	8.80	6.51	6	2.90	3.	1.31	1	9.41	9	10.72	10.	15.29	2.40	2.	2.16
4107	Bowker's Stockbridge Manure	2.88	3.25	8.92	6.58		2.52		2.39		9.10	8	11.49	9.	15.22	3.73	4.41	3.35
4108	Bowker's Hill and Drill Phos.	2.73	2.12	8.46	7.09	6	3.68	2.	1.97		10.77	8	12.74	12.	17.65	2.22	2.	2.00
4109	Crocker's Ammo. CornPhosphate	2.21	2.05	6.85	5.89	8	4.09	2.	2.25	1	9.98	10	12.23		16.46	1.85	1.60	1.67
4110	Soluble Pacific Guano	2.30	2.25	7.13	7.08	7	2.34	1.50	1.71	2	9.42		11.13	10.50	15.52	2.62	2.50	2.36
4112	Bradley's Corn Phosphate	2.44	2.06	7.65	6.69	7	2.82	2.	1.47	1	9.51	9	10.98	10.	15.52	2.10	1.50	1.89
4114	Crocker's Potato,Hop & Tob.Phos	2.28	2.	7.06	5.70	8	3.97	2.	2.56	1	9.67	10	12 23	10.	16.10	3.44	3.50	3.11
4116	Lister's Success	2.01	0.82	6.23	7.88		2.14		2.05		10.02	10	12.07		16.64	1.97	1.	1.77

*Licensed for sale in the State during the year 1891.

ANALYSES OF LICENSED FERTILIZERS.

Station Number.	BRAND.	NITROGEN.			PHOSPHORIC ACID.											POTASH.		
					Soluble.		Revrt'd.		Ins'l'ble.		Available.		Total.					
		Found.	Guaranteed.	Valuation at Station Prices.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Valuation at Station Prices.	Found.	Guaranteed.	Valuation at Station Prices.
4117	Lister's Potato Manure	2.48	1.64	$7.68	5.71	8.	3.90		2.45		9.61	9.	12.06		$15.97	3.98	4.	$ 3.58
4119	Bradley's X. L. Superphosphate	2.84	2.50	8.80	7.26	7.	2.04	2.	2.32	2	9.30	9.	11.62	11.	15.60	3.06	2.	2.75
4123	Bradley's Potato Manure	2.77	3.	8.58	4.84	5.	1.47	1.	2.23	2	6.31	6.	8.54	8.	10.84	5.10	5.	4.59
4124	Bowker's Sure Crop	0.91	0.84	2.82	8.73		2.85		2 95		11.58	8.	14.53	10.	19.42	1.13	1.	1.02
4125	Bowker's S. M. for Potatoes	3.52	2.88	10.91	5.82		3.45		1.68		9.27	7.	10.95	8.	15.16	5.94	5.	5.35
4126	Cumberland Superphosphate	2.49	2.47	7.72	5.02		7.13		1.79		12.15		13.94	12.	19.44	2.79	3.	2.51
4127	Bradley's B. D. Sea Fowl Guano	2.72	2.50	8.43	6.52	7.	2.66	2.	1.73	2	9.18	9.	10.91	11.	15.11	2.60	2.	2.34
4129	Cleveland's Superphosphate	2.36	2.05	7.32	7.24	7.	2.48	2.	1.84	2	9.72	9.	11.56	10.50	16.04	2.53	2.	2.28
4130	Cleveland Potato Manure	2.44	2.05	7.56	7.22	6.	2.35	2.	1.39	2	9.57	8.	10.96	10.50	15.63	3.64	3.25	3.28
4131	Quinnipiac P. I. Phosphate	2.31	2.05	7.16	7.08	6.	2.13	3.	2.35	1	9.21	9.	11.56	10.	15.46	2.30	1.	2.07
4133	Cleveland C. and G. Phosphate	2.49	2.05	7.72	7.24	7.50	2.14	2.	1.40	1	9.38	9.50	10.78	10.50	15.35	2.16	2.50	1.94

COMPARATIVE VALUE OF FERTILIZERS LICENSED IN 1890 AND 1891.

Of the forty brands of commercial fertilizers sold in the State during the years 1890 and 1891, seventeen standard brands have been selected for a comparison between the character of the goods sold under these brands in each of the two years. Only those brands were selected which have been sold in the State during both of the years.

AVERAGE COMPOSITION IN 1890.

Name of fertilizing ingredient.	Pounds in a hundred.	Pounds in a ton	Price per pound.	Valuation at 1892 prices.
Nitrogen	2.57	51	x 15¼	$ 7.97
Soluble Phosphoric Acid	5.83	117	x 8	9.33
Reverted Phosphoric Acid	3.28	66	x 7½	4.92
Insoluble Phosphoric Acid	2.37	47	x 2	0.95
Available Phosphoric Acid	9.11	182		
Total Phosphoric Acid	11.48	230		
Potash	3.31	66	x 4½	2.98
Total valuation per ton				$26.15

AVERAGE COMPOSITION IN 1891.

Name of fertilizing ingredient.	Pounds in a hundred	Pounds in a ton	Price per pound.	Valuation at 1892 prices.
Nitrogen	2.56	51	15¼	$ 7.94
Soluble Phosphoric Acid	6.37	127	8	10.19
Reverted Phosphoric Acid	2.90	58	7½	4.35
Insoluble Phosphoric Acid	2.06	41	2	0.82
Available Phosphoric Acid	9.26	183		
Total Phosphoric Acid	11.33	227		
Potash	3.26	65	4½	2.92
Total valuation per ton				$26.33

A comparison of the average composition of the two years shows that there is no appreciable change in the character of the fertilizers sold in the State during the past two years.

BULLETIN NO. 27.

TEST OF DAIRY APPARATUS.

The Dairy School of the University of Vermont and State Agricultural College was held at Burlington during the month of December, 1891. It seemed to the officers of the Experiment Station that this offered a good chance for obtaining some excellent data concerning the workings and effectiveness of some of the dairy implements now on the market. Accordingly, during the course a good many tests were made, and it is the purpose of this Bulletin to give the results.

The Dairy School was equipped with what was considered to be the newest and best forms of apparatus. Butter-workers were represented by the Waters hand worker, the Mason power worker, and the Fargo centrifugal worker; churns by the Moseley & Stoddard barrel churn, and the Vermont Farm Machine Co.'s square box churn. The Evan's & Heuling's Milk Cooler and Aerator was used to cool the cream and the Vermont Farm Machine Co.'s milk vat with outside water tank to hold the milk. The greatest interest of course centered in the separators, of which there were six. The Danish-Weston, 15 inch, increased capacity, was furnished by D. H. Burrell & Co. of Little Falls, N. Y.; the United States Butter Extractor, standard size, furnished by the Vermont Farm Machine Co. of Bellows Falls, Vt.; the Russian Steam Separator from P. M. Sharples, West Chester, Pa.; the De Laval Belt Separator, Alpha pattern, Acme size, the De Laval Steam Turbine Separator, Alpha pattern, A 1 size, and the De Laval Hand Separator, Alpha pattern, No. 2, furnished by the De Laval Separator Co. of New York City. The first five machines were set side by side on a stone pier and were run by a 12 horse power engine backed by a 15 horse power boiler. There was an abundance of power to run the machines at their best and still have surplus power for running the other apparatus.

One of the special features of the dairy building is the system used for heating water. It is supplied by the Vermont Farm Machine Co. and consists of a steam pipe and a water pipe uniting in what is called a "suction tee" and continuing in a single pipe terminating in a hose bibb. Each pipe has a valve of its own. If the steam valve is opened and water valve closed, steam is turned on and can be carried by hose to any part of the room. Closing the steam and opening the water valve cold water can be carried in the same hose. By opening the water valve and then gradually opening the steam valve, water of any temperature desired can be obtained, and the advantage of the suction tee is that it does away with the kicking and noise that usually accompanies the running of steam into cold water

We have five of these sets in use in the building. The sink for washing utensils is made in two parts, each supplied with the above sets. The apparatus is washed in the first sink with luke-warm water, is scalded in the second and then inverted over a jet of steam coming through a slate table adjoining the sink. This insures perfect cleansing with the least labor and time. The tempering vat for cream in the churning room is supplied by the same system with water of any temperature, while the same system is used at the green house for taking off the chill from the water used for watering the plants.

The general method of procedure during the Dairy School was as follows: The milk came in by team at about half-past eight o'clock in the morning and was mixed with that produced on the farm, aggregating about 1,000 pounds daily. This was poured into a milk vat and warmed to the temperature desired so that the entire mass of milk remained at the desired temperature for quite a while before it was run through the separator. The belief was that better results could be obtained in this way than by having the body of the milk cold and interposing a warming device between the vat and the separator so that the milk was warmed only an instant before it entered the machine. On most of the days only one separator was used, the whole thousand pounds being run through the one machine, and then the cream from that churned by itself, so that the records show the work and the results from each machine separately. This was not always the case, and the work of several days had to be thrown out of our present account because more than one machine was used to handle the milk and then the cream from the machines united to form one churning. The cream was caught in cans, run over the cooler which both aerated it and brought it to the desired temperature, set in the cream vat at about 55°, usually held there for 24 hours with ffequent stirring, churned, washed in the granular form, brought on to the worker, worked lightly, then salted three-quarters of an ounce to the pound, worked thoroughly and printed at once. When the Fargo centrifugal worker was used the butter was transferred in the granular form from the churn, salted at once at the rate of one and a half ounces of salt to the pound of butter, and run through the butter worker several times with the rolls set far apart so that the salt would be thoroughly mixed with the butter, then the rolls brought together and the butter worked as usual, and printed at once.

Samples were taken of the whole milk, skimmilk, buttermilk and butter, so that we have the figures for calculating the amount of fat that went into the machine, the amount lost in the skimmilk and buttermilk, and the amount recovered in the butter. The following tables give the most important facts concerning the handling of the milk and the cream.

It will be noted that there is considerable difference in the capacity of the various machines in amount of milk they can skim per hour, and the average figures for each will be found under the tests of each machine.

There was no test made of the power required to run the separators. It had been expected that such a test would be made, but other work intervened and prevented.

The machines were set up and tested by employes of the firms furnishing them, in all cases except the Russian Steam Separator. In all of the recorded trials except the last run of the Extractor, the entire work of running and handling the machines and the milk was done by the officers of the school and the students.

Date.	Separator.	Speed—Revolutions per minute.	Milk per hour. lbs.	Temperature of milk.	Per cent of milk taken as cream.	Per cent of fat in the skimmilk.
Dec. 2	De Laval Turbine Separator	5800	2400	80	11.8	0.05
3	De Laval Turbine Separator	----	1890	82	11.0	0.08
4	Russian Steam Separator	7100	840	83	14.3	0.25
5	Russian Steam Separator	6800	1140	--	18.5	----
	De Laval Belt Separator	6050	1080	82	13.8	----
7	Extractor used as Separator	6800	1725	82	11.2	0.10
8	Extractor used as Separator	7100	2000	88	12.8	0.17
9	De Laval Turbine Separator	6000	2070	82	10.1	0.10
10	Extractor	6000	----	60	----	0.28
11	Extractor	6000	----	59	----	0.30
12	Danish-Weston	4400	1155	83	18.2	0.07
14	Danish-Weston	4400	1300	72	15.4	0.07
15	De Laval Turbine Separator	5800	1870	79	17.3	0.10
16	Extractor	5700	----	58	----	0.24
17	Danish-Weston	4200	1700	78	14.0	0.17
18	Russian Steam Separator	8000	1020	78	17.5	0.21
19	Extractor	5600	----	--	----	0.21
21	De Laval Turbine Separator	6000	1650	78	12.7	0.05
	Extractor	----	----	--	----	----
22	Extractor	5800	----	60	----	0.20
23	Danish-Weston	4175	----	70	10.5	0.10
	De Laval Belt Separator	6100	1035	70	20.0	0.08

Date.	Separator.	PER CENT OF FAT IN				Churn used.	Temp. of Churning.	Age of Cream when Churned.
		Whole Milk.	Skimmilk.	Buttermilk.	Butter.			
Dec. 2	De Laval Turbine Separator	3.98	0.05	0.23	81.04	Box.	59°	Hr's 24
3	De Laval Turbine Separator	4.14	8.08	0.45	80.66	Bar'l.	60	24
4	Russian Steam Separator	3.93	0.25	0.23	81.82	Bar'l.	59	24
5	Russian Steam Separator and De Laval Belt Separator	3.93	....	0.10	84.16	Box.	59	48
7	Extractor used as a Separator	4.00	0.10	0.10	81.03	Bar'l.	53	24
8	Extractor used as a Separator	4.16	0.17	0.10	83.35	Box.	54	24
9	De Laval Turbine Separator	4.13	0.10	0.15	82.70	Bar'l.	58	24
10	Extractor	4.07	0.28	....	91.56	Extr'r	60	S'w't
11	Extractor	3.89	0.30	....	77.66	Extr'r	59	S'w't
12	Danish-Weston	4.01	0.07	0.10	77.16	Box.	60	S'w't
14	Danish-Weston	4.02	0.07	0.10	No Sample.	Box.	59	24
15	De Laval Turbine Separator	3.87	0.10	0.27	84.76	Box.	58	24
16	Extractor	4.10	0.24	....	77.26	Extr'r	58	S'w't
17	Danish-Weston	4.20	0.17	0.05	78.50	Bar'l.	59	24
18	Russian Steam Separator	4.40	0.21	0.05	82.19	Box.	56	24
19	Extractor	3.90	0.21	....	83.39	Extr'r	58	S'w't
21	De Laval Turbine Separator		0.05			Box.		24
	Extractor	4.20	....	....	82.78	Extr'r	58	S'w't
22	Extractor	4.20	0.20	....	80.27	Extr'r	60	S'w't
23	Danish-Weston		0.10	0.45	81.83	Box.	58	S'w't
	De Laval Belt Separator	....	0.08					

NOTES ON THE WORKING OF THE APPARATUS.

The De Laval Belt Separator: This machine was used the least of all and there is but one record of its skim-milk and none of butter-milk. The skim-milk shows 0.08 per cent of fat, when the machine was making 6075 revolutions per minute, and skimming 1057 pounds of milk per hour, at a temperature of 76°.

The De Laval Turbine Separator: This was used four times with the following average record: revolutions per minute, 5900; pounds of milk per hour, 1976; temperature of milk, 80°; average per cent of fat in skim-milk, 0.08; and, throwing out the single high butter-milk, the averages for the other butter-milks are 0.16 per cent of fat.

The Sharples Russian Steam Separator: This was used twice, making 7300 revolutions per minute, skimming 1000 pounds of milk per hour at a temperature of 81°, with an average skim-milk of 0.23 and an average butter-milk of 0.14 per cent of fat.

The Danish-Weston Separator; This was used three times, with an average speed of 4300 revolutions per minute, skimming 1385 pounds of milk per hour at 79°; the skim-milk contained on the average 0.10 per cent of fat and the butter-milk 0.08.

The Extractor was used as a separator twice, making 6950 revolutions per minute, skimming 1867 pounds of milk per hour at a temperature of 85°, and there was left on the average 0.14 per cent fat in the skim-milk and 0.10 in the butter-milk.

The Extractor was used five times as an extractor, at a speed of 5800 revolutions per minute with the milk at 59°, leaving in the skim-milk 0.24 per cent of fat.

This per cent of fat in the skim-milk is of more importance in the Extractor than in the other machines, because each of the wash waters of the butter is run back through the machine making the final quantity of the skim-milk larger than the combined weight of the skim-milk and butter-milk of other separators.

The De Laval Hand Separator: The size used was the Baby Separator, No. 2. This has been run at speeds varying from 6,000 to 8,000, skimming 330 pounds of milk per hour at temperatures from 70° to 95°, and the per cent of fat in the skim-milk does not seem to be influenced by these changes of speed or temperature, keeping very closely to 0.10 per cent fat.

In the records given above, the per cent of fat in the butter-milk has been taken in connection with the skim-milk. Strictly speaking, the character of the butter-milk should not be taken into account since it depends very much more on the man who handles the cream than on the method by which that cream is obtained. It is, however, of importance to know whether the cream as delivered by the machine is in such condition that good churning can be done with it, and the foregoing figures show that none of the machines used in these trials had any bad influence on the cream, but allow it to be handled very successfully.

One is struck at once with the average high excellence of the results. Even three years ago it would have been scarcely possible to find any separators that would do as good work as the average of these six, which is 0.12 per cent of fat in the skim-milk; and this becomes the more remarkable when we consider the quantity of milk handled per hour, as will be noticed under each machine. Special attention should also be given to the figures on butter-milk, which have an average of 0.12 per cent fat. It is but a little while ago that it was considered good work if not more than 0.50 per cent fat was left in the butter-milk and if an average of all the creameries in the United States could be taken at the present time, it is doubtful if the results would fall much below these figures, although the machines used in the creameries are the same as those that were being here experimented with. The knowledge and skill of the butter-maker controls to a large degree the quality of the butter-milk, and it speaks well for Mr. Gurler's knowledge of the subject, that, in spite of the changing conditions, the use of the various machines, and the handling of the cream by different squads of students at different times, the results should have been of such high excellence. Only two cases occurred in which the butter-milk went over 0.40 per cent fat, due in both cases to a mistake in temperature; neither of these cases have been tkaen into consideration in making any of the averages.

Most of the time Mann's acid test for cream was employed, and assisted in enabling such excellent work to be done with the churn.

There are two ways of judging of the quality of the work done by a separator. We may compare the pounds of fat recovered in the butter with the fat in the original whole milk, or we may compare the fat in the whole milk with the amount of fat lost in the skimmilk and buttermilk, These two methods would give the same results were it not for the unavoidable loss which happens in the handling of the milk and its products. In our work here under the conditions of student labor this loss was very large. There was more or less slopping from unaccustomed hands, and losses, small individually, but amounting to a large percentage on the day's work. The percentage is the greater because of the small quantity of milk handled and butter made, so that small losses make a large percentage difference; consequently when we come to use the two methods of calculation there is quite a wide variation. The averages give 0.12 per cent of fat in both buttermilk and skimmilk, representing a loss in the skimmilk and buttermilk of about three pounds of fat for each 100 pounds of fat in the original whole milk, and as the average per cent of fat in the butter was 81.5, this would make 119 pounds of such butter for each 100 pounds of fat in the whole milk.

On a basis of a comparison of the fat in the whole milk with the fat in the skimmilk and buttermilk, we have the following figures for the different machines: For the De Laval Turbine, 97.6 per cent of the fat in the whole milk, was not lost in the skimmilk and buttermilk; for the Russian Separator 94.9; for the Danish-Weston 97.4; and for the Extractor as a separator, 96.9. The work of the Extractor as an extractor cannot be judged in this way since the buttermilk is also run through the machine, and the final quantity of skimmilk is considerably larger than the combined skimmilk and buttermilk of the other machines.

Churns.—Both the box and the barrel churn were used, and so far as we could see there was no difference in the character of their work. The average fat in the buttermilk from the box churn was 0.14 per cent, and from the barrel churn 0.13.

Butter Workers.—All three butter workers did good work and gave satisfaction, the principal interest being in the operation of the Mason and of the Fargo. An examination of the tests show that there was practically no difference in the moisture in the butter from the two workers, and the men who used them were surprised to find that there was also little if any difference in the work of washing them and keeping them clean.

Aerator.—The Heuling Cooler and Aerator gave good satisfaction,and a special test showed that in a room of 54° temperature it is possible to cool down 100 pounds of milk from 82° to 44° with 417 pounds of water at 39° and that it is possible, with the use of comparatively a small quantity of water to bring the cream to within a degree or so of the temperature of the water.

In connection with the butter there is one point, however, worthy of notice. It was intended to make all the butter of the same general character, that is, to work it until the salt was evenly distributed and the water worked out so as to put it into good merchantable condition for print butter. So far as the eye could judge the butter from day to day was worked to the same quality. On analysis the butter was found to show quite a range in the per cent fat. The butter fat ranges from 77 per cent to 84 per cent. In studying these figures we find that these variations have some connection with the way the cream was handled. The sooner the cream is churned after it is separated from the milk, the firmer the butter seems to be, *i. e.* it will appear solid and marketable with a less amount of fat and a larger amount of water. The extractor butter has the most water, that churned sweet next, and the ripened butter still less, while one sample made from cream kept 48 hours had a very small per cent of water. The averages are : Extractor, five samples, 80.03 per cent of fat ; all others, 12 samples, 81.50 per cent of fat ; ripened 48 hours, one sample, 84.16 per cent fat. If, then, the creamery man can by the use of the extractor sell one and a half per cent more water and still have the butter satisfactory, that is an argument in favor of that method—if the butter is to be quickly sold, and just as much against it if it cannot get to the consumer in a comparatively short time.

Taken altogether, the figures of the work done form a valuable object lesson, and show to how high a degree of perfection dairy apparatus and methods have now attained.

REPORT OF THE CHEMIST.

By J. L. HILLS.

MUCK.

Station No.	Source.	Moisture. %	Nitrogen. %	Nitrogen in dry matter. %
4141	L. H. Felton, Franklin	82.75	0.39	2.27
4142	H. H. Hill, Isle LaMotte	84.09	0.42	2.64
4143	H. H. Hill, Isle LaMotte	88.88	0.34	3.06
4144	H. H. Hill, Isle Lamotte	87.23	0.41	3.21
4145	J. F. Day, Sheffield		0.91	

BONE MEAL.

No. 4147, sent by L. C. Fisher, Cabot, contained 3.77 per cent nitrogen and 18.89 per cent total phosphoric acid.

HIGH GRADE SUPERPHOSPHATE.

No. 4146, sent by American Phosphate and Chemical Co., Baltimore.

Total Phosphoric Acid	43.91	per cent.
Soluble Phosphoric Acid	34.68	" "
Reverted Phosphoric Acid	8.13	" "
Insoluble Phosphoric Acid	1.10	" "
Available Phosphoric Acid	42.81	" "

ASHES.

Station No.	Character.	Source.	Potash soluble in water.	Insoluble in water.	Phosphoric Acid.
4135	Lime Kiln	V. I. Spear, Braintree	2.89	1.76	1.37
4139	Canada	S. D. Whiting, Johnson	4.91		
4140	Canada	W. V. Farr, Westminster	4.42		
4148	Canada	E. O. Lee, Vernon	4.08		
4149	Hardwood	Henry Crawford, Putney	6.63		
4150	Hardwood	Henry Crawford, Putney	4.12		
4151	Hardwood	Henry Crawford, Putney	3.73		

ANALYSES OF MISCELLANEOUS FERTILIZING MATERIALS NOT SAMPLED BY THE STATION.

Station No.	Name.	Source.
4137	Soluble Pacific Guano, 4 yrs. old	T. H. Hoskins, Newport
4138	Bowker's Hill and Drill Phosphate, 3 yrs. old	E. G. Norton, Glover
4208	Great Eastern for Oats and Seeding Down	Great Eastern Fertilizer Co.
4209	Great Eastern for Corn	" " "
4210	Great Eastern for Potatoes	" " "
4152	Standard Fertilizer	W. F. Whitney, Williston
4203	Ground Bone	F. Chaffee, Rutland
4202	Tankage	" "
4201	Muriate of Potash	H. Salmon & Co., New York City

ANALYSES.

Station No.	Nitrogen.	PHOSPHORIC ACID.					Potash.
		Soluble.	Reverted.	Insoluble.	Available.	Total.	
4137	2.82	7.54	4.04	2.22	11.58	13.80	2.17
4138	3.40	2.66	4.99	6.03	7.65	13.68	3.91
4208	1.54		8.82	2.11	8.82	10.93	3.82
4209	2.73	3.23	5.66	1.19	8.89	10.08	2.33
4210	2.56	3.72	5.11	0.99	8.83	9.82	4.45
4152	2.57	6.81	2.44	2.16	9.25	11.41	2.20
4203	1.93					29.20	
4202	8.24					10.36	
4201							54.66

ANALYSES OF DRINKING WATER.

Station Number.	Character of Water.	Source of Sample.	Parts per Million.		Grains per gallon
			Free Ammonia.	Albuminoid Ammonia.	Chlorine.
1752*	Well.	R. C. Moodie, No. Craftsbury	0.61	0.205	3.75
1753*	“	“ “	0.005	0.045	3.23
1754*	“	“ “	0.03	0.115	2.78
1755	“	“ “	0.025	0.113	1.30
1756*	“	“ “	imp're	imp're	0.90
1757*	Pond Ice.	Geo. Aitken, Woodstock	0.15	0.05	0.25
1785*		N. B. Williams, No. Craftsbury	0.00	0.17	1.60
1786	Well.	J. H. Bates, Proctorsville	0.00	0.08	0.70
1787*	“	“ “	0.08	0.075	0.80
1788	“	“ “	0.015	0.065	0.80
1795		M. D. Robbins, Brattleboro	0.00	0.06	1.30
1796*	“	“ “	0.00	0.20	0.50
1797	Running.	O. A. Burton, City	0.00	0.075	1.8
1802	Well.	F. H. Crandall, Richmond	0.00	0.175	0.5
1806*	Spring.	Dr. F. D. Fally, Huntington	0.00	0.206	0.2
1807*	“	S. S. Griswold, Grand Isle	imp're	imp're	6.1
1808*	Well.	E. H. Ruggles, Westford	0.00	0.17	0.25
1809*	Spring.	H. Brainerd, St. Albans	0.33	0.175	4.25
1810*	“	R. C. Moodie, No. Craftsbury	0.10	0.06	8.60
1811*		“ “	0.065	0.055	16.36
1812		F. H. Stranahan, St. Albans	0.035	0.095	1.75
1813		H. Brainard, “	0.04	0.135	0.4
1821	“	S. L. Harris, Starksboro	0.035	0.05	0.4
1833*		Warner House, St. Albans	0.52	0.75	0.55
1834		F. H. Crandall, Richmond	0.01	0.065	0.25
1836	“	D. Powers & Son, Brandon	0.03	0.148	1.00
1837		“ “ Leicester Junct.	0.015	0.148	0.20
1838	Well.	Mrs. E. Goodrich, City	0.03	0.115	1.35
1840	Dr'vn W'l.	Franklin Co. Cr'my As. St. Albans	0.08	0.07	0.2
1841	Spring.	J. R. Houghton, Stamford	0.005	0.07	0.60
1842	“	M. Kelly, Winooski	0.02	0.11	0.70
1843	Lake	City Supply, lower service	0.005	0.16	0.20
1844	Cham-	“ filtered	0.00	0.118	0.20
1845	plain.	“ “	0.00	0.118	0.20
1846	Well.	C. E. Allen, City	0.00	0.12	11.50

Sample No. 1809 contained 42.35 per cent grains solid per gallon; 1810, 12.08; 1811, 19.08; 1834, 10.94; 1840, 13.72; 1843, 5.78, while Station No. 1846 is an exceedingly hard water. Standards of purity, etc. may be found by reference to previous reports. Samples marked with an asterisk (*) were considered unfit for use.

ANALYSES OF MAPLE SUGAR.

Station No.	SOURCE OF SAMPLE.	NATURE OF SAMPLE.	Per Cent Pure Sugar.
1722	F. H. Fullington, Cambridge	High Grade	92.1
1723	“ “ “	Low “	79.
1726	H. I. Collins, Thetford	Very Moist	76.
1738	J. M. Whitcomb, Enosburg Falls	Last run sugared off @ 226°	73.9
1739	“ “ “ “	“ “ 228°	74.4
1740	“ “ “ “	“ “ 230°	73.6
1741	“ “ “ “	“ “ 236°	75.3
1742	“ “ “ “	“ “ 238°	77.6
1743	“ “ “ “	“ “ 240°	77.
1744	“ “ “ “	“ “ 242° hot	77.2
1745	“ “ “ “	“ “ 242° cooled	75.4
1751	L. W. Foster, Cabot		84.3
1758	Col. C. S. Forbes, 1890, Fletcher		85.8
1759	“ “ “ 1891, Fairfax		83.4
1760	“ “ “ “ St. Albans		77.3
1761	E. H. Ruggles, Westford		83.5
1762	Col. C. S. Forbes, Fletcher		84.2
1763	E. S. Dunlap, Westford		84.
1770	S. M. Foster, Chelsea	Light tub	85.8
1771	“ “ “	Dark tub	82.
1772	A. Crandall, Hardwick	Light Moist tub	82.
1773	J. S. Dodge, Barton Landing	Hard tub	82.9
1774	H. W. Town, Calais	Light Moist tub	84.
1775	F. H. Rice, Cambridge	Cake	84.3
1776	“ “ “	“	83.9
1777	L. G. Chase, Fletcher	“	83.8
1778	F. W. Fay, Richmond	“	82.4
1779		1890 tub	89.1
1780		1891 cake	85.5
1781	D. T Comstock & Son, Barton	White granulated	94.6
1782	A. M. Foster, Cabot	Cake	89.1
1783	Dutton Bros., Browington	Brown granulated	93.
1784	“ “ “	Last run tub very hard	86.4
1789	T. H. Wheatley, Brookfield	Moist tub	82.5
1791	Gen. W. Grout, E. St. Johnsbury	Brown granulated	92.8
1792	“ “ “ “ “	“ “	92.
1793	“ “ “ “ “	“ “	93.3
1794	“ “ “ “ “	“ “	92.4
1799	T. R. White, Jericho	White granulated	96.
1800	A. S. Calderwood, N. Craftsbury	“ “	96.1
1801	J. S. Kinsley, N. Cambridge		86.5
1803	John Osgood, Westford		77.9
1814	Perry Chase, E. Fairfield		90.3
1815	S. W. Jewett, Weybridge		84.3
1816	A. H. Ross, Huntington		74.
1817	W. R. Dean	White granulated	94.5
1819	S. C. Scribner, Johnson	Very wet	70.
1820	“ “ “	Rather wet	78.1
1822	Allen Soule, St. Albans	Light cake middle of cream	88.2
1823	“ “ “ “	Dark cake last run	88.
1824	Thomas Mason, Passumpsic	Brown Granulated	93.
1825	D. T. Comstock & Son, Barton	White “	98.
1826	E. A. Morse	Light cake	81.
1827	D. W. Farrand, E. Hardwick	“ “	96.
1828	O. J. Blanchard, Barre	“ “	96.3
1829	B. A. Adams, Passumpsic	“ “	96.
1380	R. Spalding & Son, St. Johnsbury	Brown granulated	94.3
1831	S. D. Whiting, Johnson	Moist tub	85.8
1832	John Sinclair, “	Moist Dark tub	77.5
1835	Geo. Huntoon, Woodstock	White Granulated Crystal	99.5
1847	E. K. Montague	Light cake	88.

MISCELLANEOUS FODDER ANALYSES AND ANALYSES OF HAY FROM DIFFERENT SPECIES OF GRASS.

Station Number.	Nature of Sample.	Original Substance.						Dry Matter.							
		Water.	Ash.	Albuminoid.	Crude Fibre.	Nitrogen—Free Extract.	Fat.	Ash.	Albuminoid.	Crude Fibre.	Nitrogen—Free Exract.	Fat.	Nitrogen.	Phosphoric Acid.	Potash.
1155	Tall Fescue	16.94	6.35	6.41	28.33	38.29	3.68	7.65	7.72	34.10	46.10	4.43	1.27	0.467	1.926
1156	Red Top	18.05	6.17	6.64	27.32	38.24	3.58	7.53	8.10	33.33	46.67	4.37	1.30	0.498	2.120
1157	Alfalfa	17.72	6.80	10.35	27.11	34.34	3.68	8.25	12.60	32.94	41.74	4.47	2.02	0.829	2.003
1158	Orchard Grass	16.61	8.13	7.56	27.99	35.28	4.43	9.77	9.06	33.57	42.29	5.31	1.45	0.432	1.986
1159	Rhode Island Bent	15.89	6.55	7.18	27.10	39.26	4.02	7.79	8.54	32.23	46.66	4.78	1.37	0.465	1.924
1160	Fowl Meadow Oat Grass	16.92	4.47	5.31	27.64	43.23	2.43	5.38	6.39	33.27	52.03	2.93	1.02	0.429	1.820
1161	Fowl Meadow Grass	16.52	6.13	7.28	28.19	38.55	3.33	7.35	8.72	33.78	46.16	3.99	1.40	0.585	
1162	Timothy	20.81	4.34	4.86	27.60	37.81	4.58	5.48	6.14	34.86	47.73	5.79	0.98	0.544	1.656
1166	Timothy	22.13	3.86	4.15	24.08	42.81	2.97	4.96	5.32	30.92	54.98	3.82	0.85	0.369	1.217
1244	Green Barley	65.12	2.89	4.79	6.94	19.38	0.88	8.31	13.73	19.89	55.55	2.52	2.20	0.52	0.186
1357	Corn meal damaged by fire	6.75	1.92	10.41	5.03			2.06	11.16	5.40			1.79	0.691	
1358	Corn meal damaged by fire and water	7.87	7.68	8.75	5.63			8.33	9.50	6.11			1.52	0.164	
1411	Mixed Meal	9.22	4.44	19.47	8.84			4.89	21.44	9.74			3.43	0.846	1.457
1473	Corn Germ Feed	7.80	0.98	12.19	14.42	49.38	15.23	1.06	13.22	15.64	53.56	16.52	1.94	0.190	0.466
1474	Cream Gluten Feed	8.09	1.21	38.41	3.34	32.92	16.03	1.32	41.80	3.63	35.81	17.44	6.69	0.386	0.228
1484	Animal Meal	4.20	37.75	33.34			17.65	39.40	34.80			18.42	5.57	15.13	

EFFECT OF FERTILIZERS OF THE COMPOSITION OF CROPS.

In Bulletin No. 15 of this Station, the effect of fertilizers on the corn crop was discussed, based upon the results of its growth on a series of sixteen plots upon the Station farm. For a description of these plots the reader is referred to the Bulletin, which closes with these words (p.16):

"There remains still one view of the case to be considered, and that is, what part of the fertilizer applied to these plots remains in the ground for future crops. Although the amount of nitrogen applied was quite large, equivalent to the application of more than a ton per acre of ordinary commercial fertilizer, yet the crop contained in several instances more nitrogen than was supplied in the fertilizer. In this connection it will be remembered that in the field experiments with fertilizers on corn conducted by the University of Vermont and State Agricultural College some years ago, it was shown quite clearly that corn was a plant that did not need much artificial supply of nitrogen; that the nitrogen applied was almost always at a financial loss and that if plenty of phosphoric acid and potash were given it would supply itself with nitrogen and make a good crop.

In those plots that were fertilized with phosphoric acid or potash, the crop used in most cases less than a quarter of the phosphoric acid and less than half the potash.

These same plots without additional fertilizer have been sown this year to peas and oats, to be followed by barley, rye and grass. Each crop will be fully analyzed as above to see what effect is produced by the fertilizers and how long that effect can be traced."

The original fertilization of these crops was as follows :

Plot No.	How Fertilized.	Pounds per Acre Applied.		
		Nitrogen.	Phosphoric Acid.	Potash.
1	Nothing			
2	Nitrate of Soda, Sulphate of Ammonia and Dried Blood (Nitrogen)	70	9	
3	Plain Superphosphate (Soluble Phos. Acid)		154	
4	Muriate of Potash (Potash)			134
5	Nitrate of Soda, Sulphate of Ammonia Dried Blood and Plain Superphosphate (Nitrogen and Soluble Phosphoric Acid)	70	163	
6	Nitrate of Soda, Sulphate of Ammonia, Dried Blood and Muriate of Potash (Nitrogen and Potash)	70	9	134
7	Plain Superphos and Muriate of Potash (Soluble Phospho'c Acid and Potash)		155	134
8	Nitrate of Soda, Sulphate of Ammonia, Dried Blood, Plain Superphosphate and Muriate of Potash (Nitrogen, Soluble Phosphoric Acid and Potash)	70	163	134
9	Nothing			
10	Nitrate of Soda and Sulphate of Ammonia (Nitrogen Salts)	61		
11	Phosphatic Iron Slag (Insoluble Phosphoric Acid)		309	
12	Land Plaster, fine ground			
13	Nitrate of Soda, Sulphate of Ammonia, Dried Blood, Muriate of Potash and Undissolved S. C. Floats (Nitrogen, Insoluble Phosphoric Acid and Potash)	70	70	134
14	Nitrate of Soda, Sulphate of Ammonia, Dried Blood, Muriate of Potash and Phosphatic Iron Slag (Nitrogen, Insoluble Phosphoric Acid and Potash)	70	62	134
15	Nitrate of Soda, Sulphate of Ammonia, Dried Blood, Plain Superphosphate, Muriate of Potash and Sulphate of Iron (Nitrogen, Soluble Phosphoric Acid, Potash and Iron)	35	82	6
16	Nothing			

In 1889 and 1890 peas and oats and rye were grown. The several crops were carefully cultivated and weeded, cut when ripe, immediately weighed, cut in an ensilage cutter and sampled for analysis. Those weights and analyses enable us to calculate the crop together with the weight of dry matter and fertilizing constituents per acre. A discussion of the effect of the fertilizers on the several food constituents is for the time being deferred. In the dry substance of the peas and oats, albuminoids varied from 9.79 to 12.28 per cent and of the rye, from 5.13 to 6.89 per cent. Their respective digestion co-efficients for albuminoids as determined by artificial digestion varied from 66 to 75 and from 73 to 80.

WEIGHT OF CROPS AND DRY MATTER PER ACRE.

	Corn.		Peas and Oats.		Rye.	
Plot. 1. How Fertilized	Crop. lbs.	Dry matter. lbs.	Crop. lbs.	Dry matter. lbs.	Crop. lbs.	Dry matter. lbs.
1 Nothing	21,875	2,581	17,288	5.012	7,600	4,647
2 Nitrogen	25,000	2,860	18,688	4,837	8,825	4,997
3 Sol. Phos. Acid	28,125	2,970	17,125	4,575	8,363	4,391
4 Potash	17,500	1,620	15,725	4,250	5,738	3,151
5 Nit. and Sol. Phos. Acid	38,750	4,580	19,788	5,037	7,250	4,009
6 Nit. and Potash	21,875	2,269	17,600	4,162	4,438	2,558
7 Sol. Phos. Acid and Potash	35,000	4,000	16,975	4,300	7,125	3.741
8 Nit., Sol. Phos. Acid and Potash	30,938	3,537	18,850	4,412	7,520	4,081
9 Nothing	20,000	1,915	18,375	4,212	8,458	4,595
10 Nitrogen Salts	22,500	2,212	16,813	4,000	6,788	3,648
11 Insol. Phos. Acid	32,500	3,705	16,350	3,987	8,038	4,208
12 Land Plaster	11,250	1,004	12,288	3,062	6,250	3,166
13 Nit., Insol. Phos. Acid and Potash	15,000	1,491	15,875	4,187	7,438	3,797
14 Nit. Insol. Phos. Acid and Potash	26,250	2,650	19,475	4.600	9,225	4,712
15 Nit. Sol. Phos. Acid, Potash and Iron	33,750	3,916	21,500	5,175	9,875	5,045
16 Nothing	21,250	2,151	20,250	4,662	9,550	4,090

Plots.	Weight of Nitrogen per Acre in Fertilizer.	Weight of Nitrogen per Acre in Crop. First year.	Nitrogen remaining in soil end of first year.	Weight of Nitrogen per Acre in Crop. Second year.	Nitrogen remaining in soil end of second year.	Weight of Nitrogen per Acre in Crop. Third year.	Weight of Phosphoric Acid per Acre in Fertilizer.	Weight of Phosphoric Acid per Acre in Crop. First year.	Weight of Phosphoric Acid remaining in soil end of first year.	Weight of Phosphoric Acid per Acre in Crop. Second year.	Weight of Phosphoric Acid remaining in soil end of second year.	Weight of Phosphoric Acid per Acre in Crop. Third year.	Weight of Potash per Acre in Fertilizer.	Weight of Potash per Acre in Crop. First year.	Weight of Potash remaining in soil end of first year.	Weight of Potash per Acre in Crop. Second year.	Weight of Potash remaining in soil end of second year.	Weight of Potash per Acre in Crop. Third year.
1	0	64	—64	78	—142	48	0	7	— 7	27	— 34	22	0	59	—59	104	—163	55
2	70	62	+ 8	88	— 80	52	9	12	— 3	34	— 37	32	0	63	—63	104	—167	64
3	0	63	—63	85	—148	49	154	15	+139	33	+106	24	0	54	—54	101	—155	60
4	0	40	—40	84	—124	34	0	8	— 8	29	— 37	17	134	52	+82	88	— 6	34
5	70	81	—11	88	— 99	43	163	22	+141	32	+109	23	0	84	—84	108	—192	47
6	70	55	+15	75	— 60	25	9	12	— 3	25	— 28	12	134	57	+77	99	— 22	30
7	0	89	—89	79	—168	33	154	35	+119	30	+ 89	22	134	93	+41	96	— 55	45
8	70	83	—13	77	— 90		163	18	+145	32	+113		134	96	+38	107	— 69	
9	0	45	—45	77	—122		0	11	— 11	31	— 42		0	47	—47	96	—143	
10	61	56	+ 5	66	— 61	37	0	9	— 9	25	— 34	16	0	51	—51	81	—132	40
11	0	80	—80	71	—151		309	21	+288	31	+255		0	68	—68	86	—154	
12	0	25	—25	56	— 81	34	0	5	— 5	21	— 26	15	0	31	—31	56	— 87	36
13	70	36	+34	67	— 33	36	70	7	+ 63	26	+ 37	19	134	43	+91	91	— 0	42
14	70	67	+33	79	— 76	45	62	15	+ 47	31	+ 16	23	134	77	+57	103	— 46	50
15	35	81	—46	95	—141	47	82	22	+ 60	33	+ 27	24	67	89	—22	105	—127	54
	0	52	—52	86	—138	34	0	10	— 10	29	— 39	17	0	53	—53	96	—149	46

The effect on the dry matter of the crops may be studied by comparing the yields with the mean yield of plots 9 and 16 to which nothing was applied.

Each year plot 1 grew a much drier crop than either of the other nothing plots due probably to its position in the row. It is therefore thrown out of the calculation. Using these means we find that plots 4, 6, 10, 12 and 13 at no time produced as much dry matter as did those left unfertilized, while plots 2, 3, 5, 8, 14 and 15 every time produced more dry matter than those left unfertilized; the results on plots 7 and 11 are contradictory. Phosphoric acid is represented in the fertilization of but one of the former, in five of the latter; nitrogen in three of the former and five of the latter; potash in three of the former and three of the latter. Nitrogen and soluble phosphoric acid alone and combined bettered, while nitrogen salts and potash alone and combined lowered the yield. The complete fertilizer as a rule bettered the yield.

Bulletin 15 says on this point, referring to the effect on the first of these crops:

"Nitrogen alone and nitrogen with potash seem to have produced about the same amount of dry matter as nothing at all, while potash and plaster have apparently been detrimental to the crop. It is only when phosphoric acid in one form or another is added that any noticeable increase of dry matter occurs. Phosphoric acid alone, whether derived from dissolved rock or slag, increases the yield by half over the nothing plots, and where to this either nitrogen or potash or both is added a still further increase is obtained."

How have these fertilizers lasted? Referring to the second table we find that in six of the eight cases in which nitrogen was supplied, the first crop removed as much as was supplied, and that the second crop removed what was left in the other two. We also find all supplied potash accounted for on the harvesting of the second crop. It is otherwise with phosphoric acid, however, for all three crops together used up the supplied phosphoric acid but twice in eight cases.

Comparing the amounts of fertilizing ingredients removed on the nothing plots and on those which did not receive phosphoric acid with those which were so fertilized, we find in the corn crop that those plots receiving phosphoric acid grew crops containing twice as much of this ingredient as did the others, but that with the second and third crops this excess is but one-fourth and one-sixth over that contained in the crops of other plots. Supplied nitrogen and potash produced but little effect on the nitrogen and potash contents of the corn crop, and none whatever on those of the succeeding growths.

The results of the three years seem to indicate that phosphoric acid was most needed on this soil and with these crops, that it lasted longer and gave better returns than the other ingredients.

The soluble forms on the whole did better, but similar money value in the insoluble forms might have done as well.

LABORATORY NOTES.

SAMPLING BUTTER FOR ANALYSIS.

Is butter worked for the market well enough mixed to admit of a single sample representing it ? To test this point several samples of the same butter were analyzed, the test being repeated on several butters. Each sample was carefully taken with a butter paddle, after thorough working and from many parts of the mass. A butter paddle was used as we have found butter triers to give an unreliable sample, since they tend to push the water unduely to the outside. Such samples usually analyze lower in water than truth. Moisture determinations were made in triplicate and were generally closely concordant. Water and salt were determined by the methods of the Association of Official Agricultural Chemists, curd by the Kjeldahl method, fat by difference. Samples were prepared for analysis by melting and solidifying during cooling and shaking.

The following tabulation shows results, each bracket enclosing the samples from the same source:

Amount Butter.	Water. %	Curd. %	Salt. %	Fat. %	Extremes in % Fat.
About 15 lbs.	15.34	0.88	3.10	80.68	1.29
	16.60	0.97	3.04	79.39	
	15.93	1.00	3.00	80.07	
	11.96	1.05	3.33	79.66	
About 80 lbs.	14.90	0.92	4.69	79.49	0.16
	14.64	1.01	4.97	79.38	
	14.71	1.01	4.74	79.54	
About 15 lbs.	15.20	0.83	—	83.97	0.97
	14.27	0.88	—	84.94	
98 lbs.	15.12	1.14	—	83.72	0.91
	16.10	1.09	—	82.81	
9.65 lbs.	12.46	0.83	—	86.71	0.77
	13.05	0.66	—	86.29	
	13.18	0.88	—	85.94	
	11.34	0.66	3.27	84.73	0.34
	11.52	0.61	3.33	84.54	
	11.73	0.66	3.22	84.39	
	12.28	0.83	4.18	82.71	0.85
	12.05	0.83	5.21	81.91	
	12.33	0.83	4.98	81.86	
	12.60	0.48	2.85	84.07	1.59
	11.36	0.48	3.37	84.79	
	13.02	0.48	3.30	83.20	

It is plain from these figures *that the mechanical mixture of fat, water, casein and salt called butter worked for the market, is of very uneven composition, and that several samples from the same butter, all carefully taken, may vary among themselves in per cent of fat more than two butters from different sources.*

This seems to be particularly true of small quantities. In consequence of these facts it has been the custom of this Station for many months past to analyze two or more samples of each butter and thus minimize the error.

THE ADAMS METHOD FOR FAT; UNEXTRACTED AND FAT FREE PAPER COMPARED WITH EACH OTHER AND WITH THE BEIMLING METHOD.

A comparison was made at this laboratory of the Adams' method for fat when used with the S. & S. fat free paper and with the ordinary unextracted S. & S. paper subtracting a before determined constant. The following results were obtained: In twenty-nine out of thirty-two comparisons the unextracted paper with constant subtracted gave higher results, the average being +0.08 per cent. It also gave higher results on the same samples than the Beimling centrifugal method by +0.073. The latter averaged 0.015 higher than the S. & S. fat free paper. In the report on Dairy Products, A. O. A. C., 91, p. 18, the determinations of the chemists using both classes of paper on the same milk averaged 0.09 per cent higher with the ordinary paper. The reporter states that "after milk has been put on paper, the paper yields up more of its substance to absolute ether then it did at first." Investigation at this Station showed "that the addition of a few grains of sodium carbonate to the milk prevents it from having this action on the paper and allows a constant to be obtained and used." These tests may be summarized as follows:

Five samples, two sour, three sweet, were analyzed using the S. & S. fat free and the ordinary paper, the milks, just before putting on to the latter paper, having a few grains of carbonate of soda added to them. On the average the ordinary paper, hitherto 0.09 per cent high of the S. & S. fat free gave results 0.032 per cent low. The explanation seems to be that alkaline milk has no action on the paper and that the non volatile soda keeps it alkaline through the whole process.

In this connection a comparison of the Beimling centrifugal method with these two papers on buttermilks will be of interest. In nine comparative determinations, Beimling vs. the factored paper, the paper gave a larger per cent, the average being +0.22. In fourteen comparative determinations, Beimling vs. S. & S. fat free paper, eight times the former gave higher, five lower, one the same as the paper, the average being identical, and in but one case were the determinations more than 0.20 per cent apart.

A METHOD OF MAKING NEUTRAL AMMONIUM CITRATE AND TRI-AMMONIUM CITRATE BY DIRECT WEIGHT.

The "strictly neutral ammonium citrate" used to disolve reverted phosphoric acid has hitherto been difficult to make "strictly neutral," chemists disagreeing among themselves as to the point of neutrality. The method proposed at the Eighth Annual Convention of the A. O. A. C. by Prof. Huston now makes it an easy matter to prepare this chemical. The following method though less satisfactory was worked out at this station prior to the publication of his work and is submitted as of possible use.

Strictly neutral ammonium citrate is not a saturated compound, the tri-ammonium citrate being strongly alkaline. The latter is easily made by mixing citric acid and ammonia each of known strength (by titration) in their equivalent proportions. This mixing is of course accompanied by great heat and to avoid the loss of ammonia the following manipulation may be used. The requisite quantity of citric acid is dissolved, and most of it placed in a two-litre flask and imbedded deeply in snow or pounded ice. The rest of the acid is placed in a bulbed U-tube and connected at one end with the flask, at the other with a Richard pump. A bottle containing the requisite amount of ammonia is connected with the flask by glass and rubber tubings, and supplied with an inlet valve. The pump is started slowly and the ammonia drawn over into the acid. The snow or ice helps to keep the temperature down, the ammonia which volatilizes is caught by the acid in the U-tube and practically none escapes. The apparatus is allowed to stand until the heat has gone down and then bottle and U-tube are rinsed into the flask. Trials showed that practically no ammonia passed the U-tube and analysis of the citrate, that the theoretical amount of ammonia was present.

A tri-ammonium citrate once made, it only remains to add citric acid until the point of neutrality is reached. The relation between tri-ammonium and "strictly neutral" citrates can only be determined by the individual chemist, (though now it may be told by Prof. Huston's method), but, once determined, and the value of stocks of citric acid and of tightly bottled ammonia being known the "strictly neutral" can be made in the same way as the tri-ammonium citrate. The tests made at this station indicate that 5.6 per cent additional citric acid has to be added to the tri-ammonium to make the neutral citrate and on that basis we have several times successfully made by direct weight, a citrate strictly neutral to Squibb's litmus paper and also to Prof. Huston's method of testing.

RESULTS OF THE USE OF TRI-AMMONIUM AND "STRICTLY NEUTRAL" AMMONIUM CITRATES IN FERTILIZER ANALYSES.

These two citrates were used on twenty-four fertilizers tested in the spring of 1891. In fourteen cases comparative results agreed within 0.30

per cent, in ten they were wider apart, the widest being 1.23 per cent. In fourteen cases tri-ammonium citrate dissolved less reverted phosphoric acid, in six, more, in four, the same as the neutral, on the average dissolving 0.23 per cent less. It is note worthy that the only case where it dissolved more than 0.30 per cent more than the neutral citrate, was on goods that contained Redonda phosphate. These results as a whole are in line with the theory that alkaline citrates tend to favor the solution of iron and alumnia phosphates, and to retard that of lime phosphate.

A series of analyses using strictly neutral and slightly alkaline (2 c. c. of 20 per cent ammonia to 100 c. c. citrate) citrates on Redonda phosphate (46.03 per cent total phosphoric acid) averaged 28.21 per cent reverted phosphoric acid using neutral and 41.72 per cent reverted phosphoric acid using the alkaline citrate.

THE USE OF HYDROCHLORIC ACID IN DRYING ENSILAGE SAMPLES.

The loss in nitrogen ensuing on artificially drying ensilage has been noted by several observers. Similar results have been obtained at this station. In five cases quadruplicate samples were taken on two of which acid was sprinkled before drying, the other two being left untreated. The average of the former contained 1.92 per cent nitrogen, of the latter 1.87 per cent including the first test, which was contradictory. Omitting this the figures become 1.99 per cent and 1.89 per cent respectively. This indicates a loss of from two and one-half to five per cent of the total nitrogen present unless acid is used to prevent this disassociation.

DAIRYING.

As in former years this subject has been made the most prominent one in the experimental work of the Station and naturally is given the most space in the present report. The work this year has been more particularly in the line of handling milk rather than of its production. The different results will be found in the following pages under these heads:

I. Creamery Work.
    1. Variations in Milk.
    2. Effect of Weather on Quantity and Quality.
    3. Effect of Change from Barn to Pasture.
    4. Losses in Butter Making.
    5. Variations in Creamery Butter.
    6. Mechanical Losses in Creamery work.
    7. Relation Between Butter Fat and Butter.
    8. Pounds of Milk to a Pound of Butter.
II. Corn Fodder vs. Ensilage for Milk Production.
III. Corn Ensilage vs. Clover Ensilage.
IV. The Effect of Changing Quarters.
V. Ensilaging Turnips.
VI. Making Cheese from Different Qualities of Milk.
VII. Mechanical Losses in Cheese Making.
VIII. Creaming of Milk in Cold Setting.
IX. Cream Raising by Dilution.
X. Composition of Colostrum Milk.
XI. A New Method of Testing Cows.
XII. Abnormal Milks.
XIII. Milk Formulas.
XIV. Composition of Milk and its Products.

CREAMERY WORK.

BY W. W. COOKE AND J. L. HILLS.

During the spring of 1891 an extensive series of tests were made at the Shelburne Creamery. This creamery has about 30 patrons and the milk of each patron was sampled and analyzed separately every day for a little over a month. The samples were taken by an employe of the Station, brought at once to the laboratory and analyzed while still sweet. These samples were taken from the weighing can, after the milk had been thoroughly mixed by stirring with a dipper. A sample was also taken each day of the separator skim-milk, these samples being taken in small quantities at different times so as to represent the average working of the machine. At this creamery the cream is cooled as soon as separated and held in an open vat 24 hours. It is then hauled eight miles to the central creamery, is ripened for 24 hours and churned. A sample was taken each day of the buttermilk and also of the butter. There were recorded the weight of each man's milk and the weight of the butter, and it was assumed that the cream weighed one-fourth as much as the whole milk, since it was found by test that this was the proportion in which the separator delivered the milk. Full records of the weather were kept during this time, including temperature, rainfall, general character of the weather, time of beginning and ending of storms, etc, The test was continued from May 6th to June 7th, for all the herds, and then for six weeks longer for four herds, selected as being the best for further experimental work. At the time the test begun all of the herds were being kept in the barn, and record was made of the day when each was turned out to pasture, of the changes in feed and all changes in the composition of the herd by the addition or subtraction of milking cows.

The object of the test was to obtain information on the following points:

1. The average per cent of fat in the milk of each patron of this creamery for the month. The greatest and the mean variation from this average.
2. The relations between the quantity and the quality of the milk and the weather, feed and care of the cows.
3. Effect of change from barn to pasture.
4. Losses in butter making in the skimmilk and buttermilk and whether there is any connection between these and the weather and feed.
5. The variations in factory work in preparing butter for market; that is the variations in butter fat, water and salt in the butter from day to day.
6. The mechanical losses in creamery work.
7. The relation between butter fat as shown by analysis and merchantable butter.
8. The averages of variations in the pounds of milk to the pound of butter and whether there is any relation between the weather and these variations.

It will be at once seen what an immense number of tests and figures this experiment required. To print them would occupy more space than this entire report. It has been deemed best, therefore, to omit all of the original records and give the results in the most condensed form.

I. VARIATIONS IN MILK.

The table given below shows the variations that occurred on the large scale in average quantity and quality of these herds aggregating more than four hundred cows.

Date.	Milk Lbs.	Fat Per Cent.	Fat Lbs.
May 6.	6333	3.81	241
“ 7.	6529	3.71	242
“ 8.	6810	3.65	248
“ 9.	6906	3.66	253
“ 10.	6824	3.72	254
“ 11.	7109	3.79	269
“ 12.	7215	3.96	285
“ 13.	7629	3.83	292
“ 14.	7877	3.71	293
“ 15.	8045	3.88	311
“ 16.	8403	3.85	323
“ 17.	8301	3.87	321
“ 18.	8323	4.02	335
“ 19.	8431	3.92	330
“ 20.	8735	3.79	331
“ 21.	8745	3.73	326
“ 22.	8780	3.77	331
“ 23.	8834	3.86	341
“ 24.	8749	4.00	350
“ 25.	8979	3.83	343
“ 26.	9125	3.82	348
“ 27.	9110	3.79	345
“ 28.	9061	3.82	346
“ 29.	9326	3.64	339
“ 30.	9341	3.75	350
“ 31.	9232	3.78	349
June 1.	9331	3.76	351
“ 2.	9582	3.82	366
“ 3.	9627	3.89	374
“ 4.	9411	3.85	362
“ 5.	9361	4.03	377
“ 6.	9689	3.85	373
Average.	8430	3.82	322
Highest.	9689	4.03	377
Lowest.	6333	3.63	241
Average Variation.		0.08	

A continual increase of milk will be noticed throughout the month. This is partly due to better feed in the pasture and partly to additions of new cows. The variations in yield as they were affected by the weather and by pasturage will be mentioned later.

The use of the new rapid tests for milk has brought into prominence the fact not before suspected by the majority of dairymen that the milk of cows is very variable in quality. The figures given below represent consecutive milkings of a grade Jersey that is considered a very even tempered, robust and vigorous cow, with a good appetite and quite regular in her milk flow, seldom varying more than a pound of milk per day in the amount of milk given. The milkings were made at exactly the same time each day and no change made in her food or environment. The milk contained the following per cent of fat, 5.25, 5.15, 4.58, 4.95, 5.20, 5.10, 4.65, 4.45, 4.95, 5.38, 4.65, 4.20, 5.25, 4.75, 5.08, 4.80 in the milkings for eight consecutive days; highest per cent 5.38, lowest per cent 4.45 ; difference 0.87 per cent. If a person in taking a sample of a single milking had happened to get the 5.38 per cent he would think he had an excellent cow that took only 17¾ pounds of milk to make a pound of butter ; while if the 4.45 per cent was the one taken he would be disappointed to find that it would require 21½ pounds of milk to make a pound of butter. Even if he had mixed the night's and morning's milk together he could still have gotten a difference of 0.65 per cent between 5.20 and 4.55 at the highest and lowest tests, which would be far too wide a difference for accuracy. If, however, any two day's milk is mixed from these 8 days, the difference between the highest and the lowest results is, 0.12 per cent, which is plenty close enough for any body. In this particular case four consecutive milkings furnish a sufficiently correct sample, and under the ordinary conditions of farm practice this is practically near enough; but in our Experiment Station work for determining the general character of the milk given we do not feel satisfied with less than sixteen milkings. It has been considered even by those who are aware that single cows vary in the quality of their milk, that the milk from a large herd will be quite constant in quality, the variations in quality of the different cows balancing each other. Our tests at the Shelburne Creamery, however, show that this is not so. From the different herds there, one has been selected as a sample. The variations though large are not more than occur in all of the herds. These milkings represent the mixed milk of a herd of 13 cows.

No. of day.	Milk Lbs.	Fat Per Cent.	Fat Lbs.
1	171	3.99	6.48
2	182	4.20	7.64
3	182	3.63	6.61
4	187	3.97	7.42
5	204	4.16	8.49
6	220	4.27	9.39
7	216	4.41	9.53
8	228	4.35	9.92
9	240	4.24	10.18
10	237	4.48	10.62
11	250	4.27	10.68
12	246	4.00	9.84
13	226	4.36	9.85
14	248	4.41	10.94
15	255	4.17	10.63
16	243	4.13	10.04
17	241	4.31	10.39
18	248	4.38	10.86
19	245	4.10	10.05
20	264	3.91	10.33
21	243	3.75	9.11
22	241	4.29	10.34
23	250	4.31	10.78
24	262	4.10	10.74
25	262	3.91	10.24
26	272	4.04	10.99
27	260	3.88	10.09
28	255	4.62	11.78
29	256	4.59	11.75
30	262	4.39	11.50
31	266	4.34	11.54
32	261	4.25	11.09
Total and Average.	7,623	4.19	319.84

These variations need especially to be studied at the present time because many creameries are beginning to pay for milk according to test. In most creameries milk is paid for once a month and it is necessary to get some per cent of fat that shall correctly represent the average quality of the milk for the month. Theoretically the only way to be sure of a correct average is to analyze a sample of each day's milk, but this means so much work that no one could afford to do it; but in practice it is found that a much simpler way answers just as well. The milk varies widely from day to day it is true, but these variations balance each other and the average of a small number of analyses taken at random through the mouth is in practice sure to give the same result as the average of the analysis of each day's milk separately.

The highest per cent of fat during the month was 4.62 and the lowest 3.63 or a difference of 0.99 per cent. The average of all the analyses was 4.19 per cent, so that practically the same result is obtained whether each day's milk is multiplied by its own per cent, and then the daily amounts of fat are added, or whether the daily amounts of milk are added and the whole multiplied by the average per cent. If now we select each fourth day during the month, we have the following average:

1, 5, 9, 13, etc	4.14	per cent.
2, 6, 10, 14, etc	4.31	“
3, 7, 11, 15, etc	4.14	“
4, 8, 12, 16, etc	4.17	“

True average 4.19 per cent. Greatest difference from true average when sample is taken once in four days, 0.06 per cent. This mean difference is called the probable error, and is another way of saying that when samples are taken once in four days instead of every day, there may be an error of 0.12 per cent and there probably will be an error of 0.06 per cent. This greatest error is not large, and the probable error of 0.06 per cent is too small to be noticed.

Let us see if it is possible to analyze still less often and yet get correct results.

Suppose a sample is taken only once in eight days, then the following results would be obtained:

1, 9, 17, 25	4.06	per cent.
2, 10, 18, 26	4.28	“
3, 11, 19, 27	3.97	“
4, 12, 20, 28	4.13	“
5, 13, 21, 29	4.22	“
6, 14, 22, 30	4.39	“
7, 15, 23, 31	4.31	“
8, 16, 24, 32	4.21	“

True average 4.19 per cent. Greatest difference from the average when a sample is taken only once in eight days 0.22 per cent, and there probably will be an error of 0.10 per cent.

This error is much smaller than most persons would expect, and for fear that it may be thought that this is an exceptional case, the same calculations have been made in the cases of a second herd of 19 cows that gave 13,506 pounds of milk during the month and of a third herd of 13 cows producing for the month 7,442 pounds of milk.

In the second case the greatest difference for sampling every four days was 0.06 per cent and the probable error 0.04, and for once in eight days 0.14 per cent and 0.05 per cent respectively. While the third herd gave 0.05 per cent and 0.03 per cent for every fourth day, and 0.19 per cent and

0.10 per cent for the eight days. It will be noticed that the figures for the three herds differ but little. The average of all of them shows that if a sample is taken every eight days, or what is equivalent, once a week, the greatest error will not be over 0.22 per cent, and there will probably not be a difference from the truth of more than 0.08 per cent, and by doubling the frequency of the sampling, and taking two samples a week, the probable error is reduced to 0.04 per cent.

This error of 0.04 per cent is way within the limits of the error of analysis and is plenty close enough for practical work.

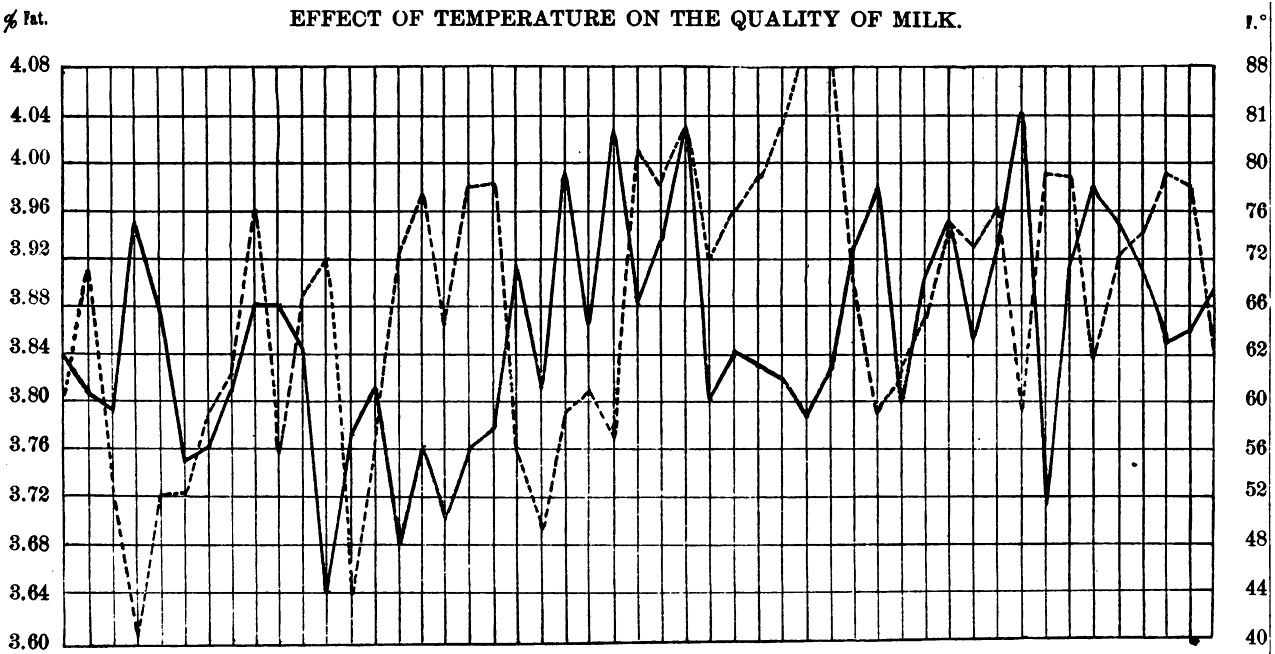
It can be said then that there is no need of analyzing every day, or of taking a composite sample that shall represent each day, but that if eight samples are taken during the month the result will be sufficiently accurate.

There is no necessity of analyzing all of these eight samples separately. Our method as outlined in Bulletin 21, is to have a jar for each patron and put into it a sample from some two days of the week, not having the days the same for all the patrons, and sampling the milk of a given patron on different days in different weeks. The samples are kept from souring by adding corrosive sublimate, and at the end of the week or month the mixed sample is analyzed.

2. EFFECT OF WEATHER ON QUANTITY AND QUALITY OF MILK.

During the month when the milk of all the dairies was tested there occurred thirty-one chances for comparing the *quality* of milk with the temperature, there being 17 days of rising temperature, 10 days of falling, and 4 days of stationary temperature. On 15 of these days when the weather became warmer the fat in the milk decreased, and as the weather became colder the fat increased ; that is the quality of the milk changed in the opposite direction from the temperature. In seven cases the change was in the same direction, and in five cases there was no change. In the next seven weeks when tests were made of only four of the herds, there are 18 days of rising temperature, 15 days of falling and 10 days of stationary temperature. In 22 cases the quality of the milk changes in the opposite direction from the temperature, and on 11 days in the same direction. Thus during the entire periods almost two-thirds, or exactly 61 per cent of the changes in quality are in the opposite direction to the changes in temperature. During the 14 days of stationary temperature there were eight cases of an increase in quality, and six of a decrease, some of these changes being quite marked. There would seem then to be a general tendency of the quality of the milk to become richer when the temperature was falling and less rich during a rising temperature. The changes in quality in the opposite direction to temperature were generally more marked than those in the same direction. During the first month there were ten marked changes in quality extending over two or more days, six of an increase in quality, and four of a decrease. Six out of these ten changes were directly opposite to the temperature; one was in the same direction; during the other three there was both rising and falling temperature. The four marked changes in quality extending over three or more days that occurred during the next six weeks are all in the direction opposite to the changes in temperature. It does not seem possible that this large preponderance of evidence in one direction can be accidental and it would seem to indicate that this is a tendency of the cow's nature. It has been suggested in explanation of this, that during cold weather the cow actually consumes more food and that thus there is present in the system a larger amount of material from which to produce richer milk. The accompanying chart shows to the eye in how large a proportion of cases the lines representing temperature and quality move in opposite directions, quality rising when temperature falls and falling when temperature rises.

EFFECT OF TEMPERATURE ON THE QUALITY OF MILK.



The black line represents the average per cent of fat in the milk.
The dotted line represents the temperature.
Each space from left to right represents one day, beginning May 15 and ending July 4.

The changes in *quantity* of milk are not so easy to trace since this was affected not only by the weather but by the addition of new cows to the herds, and the change from barn to pasture, the tendency being to increase the quantity almost without a break up to the height of the season at June 23, and a constantly diminishing quantity thereafter. During the period of increasing yield, previous to the middle of June, there seems to be some connection between quantity of milk and the temperature, since each case of a decrease in quantity is at or within 24 hours of a sharp fall of temperature. After the middle of June but little connection can be traced.

The *quantity of butter fat* produced does not seem to have varied much from either cause. The quantity of fat is dependent on both quantity of milk and quality of milk, and since these two seem to have been affected in opposite directions by changes in temperature the total effect on quantity of fat is too much obscured to be determined.

During this test there were several heavy storms. The *amount* of milk delivered immediately following these was larger than just preceding, but it is not possible to say whether this increase was due to water getting into the milk before it left the cows or after. The changes in quality due to these storms, if judged by the milk delivered the next morning after the storm, cannot be determined but it is noticeable that the second day after the storm, quality rises while quantity shrinks. There were sixteen rain storms from May 6 to July 24, and the quality of the milk the next morning after each storm showed six cases of increase in quality, seven of decrease in quality and three stationary. Some of these changes were slight, some were decided and they were not always in accord with the size of the storm. Quality and quantity changes in connection with the six heaviest storms are shown in the following table. It will be seen that in four cases more milk is given the morning after the rain and in five cases the delivery of the second morning after the rain shows less milk, but that that milk is always richer.

Date.	Milk Lbs.	Milk Per cent	Rain in inches.	Temperature.		
				9 a. m.	2 p. m.	9 p. m.
May 15.	8045	3.88		45°	71°	59°
" 16.	8403	3.85	1.6	50	52	39
" 17.	8576	3.87		40	40	40
" 18.	8253	4.00		44	52	38
" 29.	9326	3.76		66	77	62
" 30.	9341	3.77	0.5	61	66	59
" 31.	9397	3.77		62	78	67
June 1.	9331	3.75		74	78	66
" 2.	9582	3.81		54	56	54
" 3.	9627	3.89	0.5	47	49	43
" 4.	9736	3.83		43	59	46
" 5.	9361	4.01		51	61	49
July 1.	1552	3.85		70	78	71
" 2.	1554	3.86	0.5	65	64	60
" 3.	1490	3.89		64	76	63
" 4.	1444	4.18	0.5	62	66	62
" 5.	1481	4.02		57	58	56
" 6.	1438	3.99		54	59	58
" 7.	1403	4.31		58	65	57
" 8.	1421	4.20	0.6	56	65	59
" 9.	1389	4.18		61	71	60
" 10.	1420	4.17		60	80	66

If we consider these changes to be due to the effect of rain storms they would seem to indicate that cows in flush of milk on pasture feed give as much or more milk and of just as good quality in bad weather as in fair weather and that when the storm is over they give a less quantity of richer milk. The cows do not appear to have made any change in quantity or quality of milk on the approach of a storm and no connection is traceable between the storms and the pounds of butter fat produced.

3. THE EFFECT OF CHANGE FROM BARN TO PASTURE.

This was very marked in the case of all of the herds. After making allowances for the milk of fresh cows added to the herds, there is still left an increase of about 16 per cent in quantity of milk due to the pasturage, notwithstanding the fact that most of the herds had grain while in the barn and none on pasture. There was also a gain in quality of milk on pasture amounting to about a third of a pound of butter to each hundred pounds of milk. These two results combined make the entire effect of change from barn to pasture a gain of about one-fourth more butter per day per cow.

4. LOSSES IN BUTTER MAKING.

The true test of the excellence of the work of a creamery, so far as the mechanical part is concerned, is the amount of fat saved in the butter for each 100 pounds of fat brought in the whole milk. This will be found to vary largely from one creamery to another, and in the same creamery from day to day. In our work we found out by analysis the amount of fat in the whole milk, and by analyzing the skimmilk and buttermilk we were enabled to know how much of the fat was lost in the process of manufacture. The calculations were made as follows, taking, for example, the first day : Pounds of fat in whole milk, 241.16 ; per cent of fat in skimmilk, 0.15 ; and in the buttermilk, 0.45 ; pounds of fat lost in the skimmilk, 7.12; and in the buttermilk, 5.87. Total fat loss, 12.99 pounds; 241.16 minus 12.99 leaves 228.17 pounds saved in the butter ; 228.17 divided by 241.16 gives .95 as the per cent of churnability.

No. of Days.	Fat. lbs.	Skim-milk. Per cent.	Butter milk. Per cent.	Skim milk. lbs.	Butter milk. lbs.	Churnability.
1	241.16	0.15	0.45	7.12	5.87	95
2	241.11	0.15	0.45	7.28	6.05	95
3	248.08	0.20	0.65	10.22	9.23	92
4	252.46	0.25	0.75	12.95	10.85	91
5	250.92	0.13	0.75	6.53	9.45	94
6	269.21	0.15	0.50	8.00	7.43	94
7	285.17	0.20	0.48	10.82	7.12	94
8	292.25	0.15	0.60	10.08	9.47	93
9	292.73	0.15	0.63	8.86	10.30	93
10	308.55	0.20	0.95	11.96	15.69	91
11	423.13	0.23	0 75	14.49	13.39	91
12	312.16	0.13	0.63	7.96	10.64	94
13	333.97	0.10	0.35	6.26	5.92	96
14	329.54	0.25	1.03	15.69	18.18	90
15	326.07	0.23	0.70	15.07	12.76	92
16	315.51	0.25	0.60	16.40	10.89	91
17	327.03	0.18	0.75	11.85	13.72	92
18	341.48	0.23	0.83	15.23	15.27	91
19	322.28	0.18	0.75	11.81	13.48	92
20	333.26	0.20	0.50	13.47	9.32	93
21	317.94	0.28	0.63	13.37	12.59	90
22	359.85	0.20	0.78	13.66	14.86	92
	Average	0.19	0.60	11.60	10.30	92.5

The work of the separator was on the whole satisfactory. The average fat in the skimmilk was 0.19 per cent, and amounted to 11.6 pounds per day, or 3.64 per cent of the fat in the whole milk. This is probably less than one-third of the average amount of waste in this country from shallow setting, and considerably better than the average deep setting.

The average amount of fat lost each day in the buttermilk was 0.60 per cent, equaling 10.3 pounds per day or 3.23 per cent of the total fat in the cream. This is higher than it ought to be and higher than we found in testing some other creameries. Nevertheless, even this high per cent is much less than our grandmothers used to lose in the old dash-churn, and is less than is now lost by churning the cream from shallow setting, and is probably a little less than the average results obtained by our best dairymen from the cream raised by deep cold setting. A well known writer on dairy topics has made the statement that, on the average, in private dairies not more than 75 per cent of the fat in the whole milk is recovered in the butter. As compared with this the average of 92.5 per cent shows that this creamery did creditable work. On its best day, only 4 pounds were lost out of 100, and if it is possible to do this once, it should be equally possible by taking sufficient care to do it every day, and it is probable that before many years dairymen will have learned the principles and the practice so thoroughly that they will be able to save in the butter-tub nearly all the butter fat yielded by the cows.

In these tests it was not possible to establish any relation between the weather or feed and the results of skimming and churning. In other words, there is nothing to indicate that the change from barn to pasture, i. e., from dry feed to succulent, or the changes of the weather had any influence on the work of the separator or any effect on the churnability of the cream.

5. VARIATIONS IN CREAMERY BUTTER.

It is generally considered that the butter from a given creamery is quite constant in character. It is handled each day with the same tools, in the same manner and salted at the same stage with the same proportionate amount of salt. Yet the figures given below show that even under these uniform conditions there is quite a lack of uniformity in the product. The variation in water is the most striking, some of the butter containing nearly a third as much again as that of other days. This butter was packed after once working and would therefore be more likely to vary in amount of water than if it had been held in a cool room for twelve hours and then reworked.

Date.	Water.	Fat.	Salt, curd and ash.
May 7	12.10	83.44	4.46
8	12.28	83.25	4.47
9	11.45	83.18	5.37
10	11.01	84.08	4.91
11	11.74	84.04	4.22
12	12.33	83.87	3.80
13	12.50	82.58	4.92
14	12.13	83.39	4.48
15	11.71	83.85	4.44
16	12.48	82.98	4.54
19	13.65	81.52	4.83
20	14.70	79.82	5.48
21	13.49	80.89	5.62
22	14.64	79.65	5.71
23	13.30	82.73	3.97
24	12.76	83.24	4.00
25	12.12	83.72	4.16
26	11.98	83.63	4.39
27	12.33	83.36	4.31
29	11.58	84.14	4.28
30	10.43	84.96	4.61
31	10.83	85.14	4.03
June 1	11.85	83.11	5.04
2	15.24	79.93	4.83
3	11.65	83.01	5.34
4	12.39	82.95	4.66
5	10.68	84.66	4.66
Average.	12.35	82.93	4.65
Highest.........	14.70	85.14	5.71
Lowest..........	10.43	79.65	3.80

6. MECHANICAL LOSSES IN CREAMERY WORK.

The amount of fat in the milk as delivered at the creamery was determined with a good deal of care and probable accuracy. There was also determined the amount of fat that went into the skimmilk, the buttermilk and the butter. The sum of these three should equal the first and the differences if any represent the mechanical losses. In the accompanying table these losses or variations are seen to be sometimes a gain instead of a loss. This means of course a mistake in the work, and the error is most likely to have been in the sampling of the butter as when butter is worked but once it is quite difficult to get a sample or collection of samples that will correctly represent its average character. The average mechanical loss of 3.27 pounds or 0.86 per cent is probably quite close to the truth and represents the amount of butter lost by sticking to the various utensils.

Date.	Pounds milk to 1 lb. butter.	Pounds butter to 100 lbs. fat.	Mechanical loss or gain. lbs. of fat.	Mechanical loss or gain. per cent.
May 6	22.7	115.6	+ 5.22	+2.15
7	23.9	112.9	— 0.03	0.00
8	24.15	113.6	+ 6.13	+2.47
9	24.65	110.7	+ 5.26	+2.08
10	24.3	110.6	+ 0.87	+0.34
11	24.4	108.0	— 8.21	—3.05
12	22.45	112.5	+ 2.90	+1.02
13	23.2	112.8	— 2.05	—0.70
14	23.8	113.1	+ 2.69	+0.93
15	32.5	109.9	+ 3.37	+1.09
16	23.65	109.9	— 0.73	—0.23
17	23.3	110.8		
18	22.85	108.8		
19	24.15	105.6	—12.01	—3.64
20	24.35	108.3	—17.09	—5.16
21	23.55	113.7	+ 0.99	+0.30
22	24.	110.6	—13.24	—4.00
23	24.	107.8	— 4.21	—1.25
24	22.4	111.6		
25	23.55	111.0		
26	24.	108.9		
27	24.4	108.1	— 6.66	—1.93
28	24.3	107.8	— 0.26	—0.08
29	24.8	110.9		
30	25.25	105.6		
31	23.8	111.2		
June 1	23.45	113.4	+ 8.00	+2.28
2	24.1	108.5	—20.20	—5.52
3	24.25	105.6	—18.81	—5.02
4	23.75	109.3	— 3.90	—1.08
5	——	——		
6	24.85	104.4		
Average.	23.87	110.1	— 3.27	—0.86
Max.	22.43	115.6	—20.20	—5.52
Min.	25.25	104.4	— 0.03	0.00
Ave. var.	0.52	2.2	6.49	2.01

7. RELATION BETWEEN BUTTER FAT AND BUTTER.

Since creameries began to pay by test and farmers to test their cows, the inquiry is often heard as to how much butter should be made from milk with a given analysis. It is evident that no set rule can be given, since varying amounts may be lost in the skimmilk and buttermilk and the butter may contain widely varying amounts of fat, water and salt. In Bulletin No. 16 of this Station, figures were given showing that the average of all the tests of creameries made up to that time was 108 pounds of butter for each 100 pounds of butter fat in the whole milk. The Shelburne Creamery has done a little better than this on the average, though the table shows wide differences on different days. The best of work should yield fully 15 per cent more butter than butter fat, though this result would be but rarely obtained in creamery work.

8. POUNDS OF MILK TO ONE POUND OF BUTTER.

Many will be surprised to see the variations that occurred from day to day in the amount of milk needed to make a pound of butter. Many creamery owners believe that the quality of milk they receive changes but little, and blame the butter maker whenever a larger amount than usual of milk is required for a pound of butter. The figures already given of the variations in the quality of the milk from day to day show that this blame may be unmerited. They show that a variation of two pounds of milk to the pound of butter is to be expected during a month's work and can be easily accounted for by the variation of the quality of the milk.

II. CORN FODDER vs. CORN ENSILAGE.

BY W. W. COOKE AND J. L. HILLS.

When the corn was harvested at the Station farm in the fall of 1890, two rows were put in the silo, the next two stooked, the next two in the silo, etc., through the whole piece. There were several pieces of corn cut of different degrees of maturity, varying from that which was drilled so thick that nothing but immature ears could grow, to that which was fairly well eared and just beginning to glaze. The half for stooking was unweighed and unsampled, it being assumed that its weight and composition were the same as that put in the silo. That which went into the silo was brought to the barn, weighed on the hay scales, then run through the cutter into the silo. While it was being fed to the cutter, an armful was taken occasionally for analysis. This armful was taken without a great deal of care so as to have it an average sample of the corn. That is, there was no endeavor made to have each armful a representative of the load, but as the man was handling the corn to the one at the machine he was stopped every once in a while, that is, either three or four times during a load, with whatever he happened to have just then in his arms. This armful was weighed at once with the greatest of care and thrown into a pile. The total amount put into the silo was about 12 tons, and the sum of all the samples taken was 957.75 pounds.

After the silo was filled with the corn for this experiment, it was covered with boards and then about three tons of cut ensilage put on top, which was then also covered with boards and weighted with stone, about 50 pounds to a square foot. Under the corn for this experiment there were put into the silo some four tons of similar corn from the same field and covered with a light layer of boards so that the ensilage for this particular experiment was in the middle of the silo. Thus no extra spoiled ensilage on the top or on the bottom would fall on the ensilage of this test, and as a result there was practically no spoiled ensilage from beginning to end.

The 1000 pounds taken out for the sample was run through the cutter onto the barn floor, cutting it into quarter of an inch pieces. It was shoveled over and over to mix it thoroughly and ten samples of 15 to 20 pounds each taken for analysis. These samples were weighed accurately when taken, put in paper bags, brought to the Station and at once put into the drier. That which was left on the barn floor, after taking out the ten samples for analysis, was carefully gathered up and weighed, this weight added to that of the samples and the whole calculated back to the original weight of the armfuls as taken from the load. It is known that this sampling was the most elaborate and accurate that has ever been undertaken at this Station and it is believed that it is as accurate as any that has ever been done at any other Station.

The half of the corn that was to be stooked was brought to the barn and put in stooks on a slightly sloping piece of ground, just outside the barn. The stooks were made rather large, to contain from four to eight hundred pounds. The tops were drawn together as tightly as two men could do it with a large rope and then bound with cord. After they had stood and shrunk for about two weeks the bands were tightened. This caused them to keep the rain and snow out quite completely, and the fodder kept in a most excellent state of preservation. When the last was fed in the spring some time after the snow had gone, it was still bright green in the middle of the stooks and showed no signs of heating or decay.

After feeding out the top layer of ensilage, about November first, the experiment proper was started. Three cows were selected, Betsey, Topsy and Dolly, all fresh in milk. Two cows were put on ensilage and one on corn fodder with 8 pounds of hay and 8 pounds of grain. The hay and grain were fed the first thing in the morning, that is, 4 pounds of each, and when that was all eaten up clean, then the cows were given all they would eat of the ensilage, or the corn fodder, and whatever they did not eat was weighed back so that the orts consisted entirely of ensilage or corn fodder. They were watered once a day, at noon, and the same feeding repeated at night. They were not fed anything at noon.

When the corn fodder was fed one of the stooks was brought on to the barn floor, cut about a quarter of an inch in length and fed, samples being taken from each stook as soon as it was cut up. These samples being taken in triplicate or quadruplicate from 8 to 15 pounds in weight and brought at once to the Station and the whole sample put into the drier.*

A sample of the ensilage was taken once a week in the following manner: Several holes were dug in the ensilage, going down about as far as was expected would be fed out during the next week. The ensilage from these holes was thrown out, shovelled over, mixed up thoroughly and then three or four samples from the whole lot were put in paper bags and dried as usual.

*The following method is used at this Station for the preparation of fodder samples for analysis. If the sample has been already cut, it is at once put on the sieves in the drier. If the fodder is long it is run through a small hand hay cutter and cut into about half inch lengths. The whole mass of the sample is put into the drier, whether it is 2 pounds or 25 pounds. It is dried until the material is crisp enough to grind, then it is taken out and the whole, while it is still warm, run through a grinder without loss, the greatest care being taken to grind the material up and after to sweep up the dust and in every way to do the grinding with the least possible mechanical loss. It is afterwards gathered together, mixed up, weighed and three samples of 5 grams each taken out for drying in the bath to constant weight. At the same time a sample of 50 to 100 grams is taken out, weighed, and again without loss, ground and sifted until it all passes through a sieve of 50 holes to the inch. This is then again weighed, bottled tightly, and constitutes the analytical sample from which moisture, etc., is determined. By means of these several weights, on supposition that there has been no mechanical loss, it is possible to calculate back to the original substance.

In feeding out the ensilage in this experiment it was found that the surface exposed, 6½x12½ feet, was too great for the small amount of ensilage eaten by the two cows. The air worked into the ensilage faster than the cows ate it, so that after the first six weeks it began to deteriorate in quality, though at first it was considered to be first class ensilage. It became necessary to have it eaten faster and for this purpose other animals were added, the poorer parts of the ensilage being given to the new animals. Even then it was not eaten fast enough to be at its best and the general character of the ensilage for the last two months of the test was not so good as that fed to the non-experimental cows from the other silo.

On the whole, then, the ensilage did not have a fair show in these tests. On the other hand there were outside losses in the corn fodder which probably about balanced the poor quality of the ensilage. These losses arose from the rats and mice which burrowed through the snow and worked a good deal in the lower part of the stooks, so that on the whole there could not have been much difference in the food value of the two fodders. The results as obtained in actual farm practice ought not to be much different from those obtained here, though, of course, it is to be remembered that the character of the corn fodder was considerably better than that usually fed by farmers.

The cows were kept four weeks on the same feed and then shifted, those having ensilage being changed to corn fodder, and vice versa. The last twelve days of the four weeks the milk of each cow was analyzed and the analyses considered to represent the average quality for the period, the last twelve days of which was taken as the real test. The animal was weighed the last three days before shifting. The amount of water drank was also recorded for the last week of each period, while the temperature of the stable and the temperature of the water drank was taken the last twelve days of each period. The weight of each milking was recorded.

CHANGES IN COMPOSITION DURING ENSILAGING AND OUTDOOR CURING.

CORN ENSILAGE.

Date.	Water.	Dry Matter.	Composition of Dry Matter.						
			Albuminoids.	Fat.	N. Free Extract	Crude Fiber.	Ash.	Phos. Acid.	Potash.
As put in Oct. 2-3,'90.	81.80	18.20	8.97	2.44	57.04	25.03	6.52	0.32	1.65
Nov. 1, 1890	83.60	16.40	10.27	3.13	45.75	30.60	1023	0.23	2.90
" 5, "	85.06	14.94	8.91	3.08	45.10	34.74	8.16	0.23	2.88
" 10, "	85.76	14.24	9.39	3.01	43.96	35.48	8.12	0.24	2.92
" 21, "	85.19	14.81	9.12	3.03	44.26	34.78	8.79	0.23	2.88
Dec. 3, "	82.64	17.36	10.62	3.23	47.26	29.66	9.21	0.44	2.23
" 12, "	82.08	17.92	9.45	3.52	51.49	28.38	7.15	0.45	2.26
" 19, "	83.30	16.70	9.59	3.24	47.44	31.71	8.00	0.50	1.74
" 31, "	81.90	18.10	10.24	3.36	49.19	29.29	7.92	0.45	2.25
Jan. 7, 1891	82.17	17.83	10.02	3.48	50.93	28.25	7.32	0.45	2.26
" 24, "	83.29	16.71	10.03	3.30	48.20	31.30	7.16	0.50	1.73
" 31, "	82.90	17.10	10.63	3.23	47.22	31.47	7.43	0.49	1.73
Feb. 7, "	83.90	16.10	11.05	3.21	46.96	32.26	6.52	0.49	1.72
" 21, "	83.39	16.61	10.88	3.16	46.22	33.14	6.60	0.45	1.45
" 26, "	83.03	16.97	10.71	3.14	46.03	32.94	7.14	0.46	1.46
Mar. 9, "	83.19	16.81	9.94	3.29	48.00	32.39	6.37	0.46	1.49

CORN FODDER.

Date.	Water.	Dry Matter.	Composition of Dry Matter.						
			Albuminoids.	Fat.	N. Free Extract.	Crude Fiber.	Ash.	Phos. Acid.	Potash.
As stooked Oct. 2-3, 1890.	81.80	18.20	8.97	2.44	57.04	25.03	6.52	0.32	1.65
Nov. 1	77.65	22.35	9.40	1.99	54.93	26.75	6.92	0.42	2.40
5	77.03	22.97	9.18	2.01	55.38	26.39	7.02	0.42	2.41
10	75.16	24.84	9.27	2.01	55.61	26.07	7.03	0.42	2.43
21	79.60	20.40	8.51	1.82	50.27	30.87	8.52	0.43	2.45
Dec. 3	74.10	25.90	8.61	1.97	54.29	27.97	7.16	0.40	1.52
12	69.43	30.57	8.75	2.04	56.21	26.67	6.32	0.38	1.47
19	66.33	33.67	7.88	2.22	61.12	24.26	4.51	0.47	1.64
31	71.20	28.80	8.26	2.10	58.04	26.53	5.06	0.38	1.48
Jan. 7	77.10	22.90	8.12	1.95	53.84	30.26	5.82	0.38	1.45
24	77.67	22.33	9.34	1.98	54.65	27.55	6.49	0.46	1.62
31	80.92	19.08	10.18	1.87	51.49	29.18	7.27	0.47	1.67
Feb. 7	73.09	26.91	10.44	1.98	54.73	27.38	5.48	0.46	1.63
21	81.46	18.54	10.54	1.77	48.81	30.64	8.26	0.48	1.97
26	84.05	15.95	9.36	1.62	44.71	35.63	8.67	0.50	2.04
Mar. 9	71.44	28.56	9.87	1.97	54.32	27.75	6.09	0.49	2.00
19	70.39	29.61	10.48	1.90	52.41	29.25	5.94	0.41	1.66
27	61.45	38.55	9.99	1.92	52.83	29.55	5.71	0.49	2.00

LOSSES.

		Total Weight. lbs.	Water. lbs.	Dry Matter. lbs.	Albuminoids. lbs.	Starch, Sugar&c lbs.
Corn Fodder.	Put into Stooks	24,858	20,334	4,524	406	2691
	Taken fromStooks	14,262	10,607	3,654	338	2054
	Shrinkage	10;596	9,727	870	68	637
	Per ct. Shrinkage	43	48	19	17	24
Corn Ensilage.	Put into the Silo*	24,858	20,334	4,524	406	2691
	Taken from Silo	20,532	17,101	3,623	345	1840
	Shrinkage	4,335	3,231	901	51	851
	Per ct. Shrinkage	18	16	20	13	31

*Out of the half that was to go into the silo, the samples for analysis were taken ; the above figures are calculated for the whole amount from the weights obtained for the portion actually ensilaged.

The record of the changes and losses is in the above table. It will be seen that the stooked fodder lost most weight as would be expected, and this extra loss of weight was mostly water, since the dry matter taken out of the stooks and out of the silo is almost exactly the same. The stooked fodder looses the more in albuminoids and the ensilage the more in the heat producing elements, starch, sugar, etc.

AVERAGE COMPOSITION.

	Both as Put in.	Ensilage as Fed.	Corn Fodder as Fed.
Water	81.80	82.34	74.37
Dry Matter	18.20	17.66	25.63
Albuminoids	1.633	1.686	2.369
Fat	0.444	0.542	0.504
N. Free Extract	10.382	8.920	13.899
Fiber	4.555	5.265	7.212
Ash	1.186	1.247	1.646
Phosphoric Acid	0.059	0.072	0.105
Potash	0.301	0.333	0.473

RELATION OF ENSILAGE TO TOTAL WATER CONSUMED.

During the last twelve days of each period the water given to the cows was weighed, and from the analyses of the fodder and grain consumed there is known how much water was contained in the food, so tha tthe total water taken into the system is known. Every one who feeds ensilage, notices that cows drink less water with ensilage than with dry fodder, but the figures given below show that the water in the ensilage was more than enough to balance the decrease in water drank.

Period.	Amount of Water Consumed per Period.					
	Drank		In Food		Total	
	Ensilage Periods.	Fodder Periods.	Ensilage Periods.	Fodder Periods.	Ensilage Periods.	Fodder Periods.
Betsy.						
I.	384		757		1140	
II.		592		425		1017
III.	384		742		1126	
IV.		423		567		990
Topsy.						
I.	292		681		973	
II.		480		342		821
III.	319		687		1006	
IV.		335		297		631
Dolly.						
I.		560		470		1030
II.	405		678		1083	
III.		459		388		846
IV.	398		500		898	
Total	2182	2849	4035	2489	6226	5435

Every time that the cows changed from ensilage to corn fodder they drank more water, but not enough to make up for the additional water in the ensilage. So that, although the corn fodder used in this experiment was itself more than half water, yet **more water was taken into the system with ensilage than with corn fodder.**

RELATION OF WATER CONSUMED AND MILK FLOW.

There is a popular notion that the more water a cow can be induced to take into the system the more milk she will yield. Let us see whether that holds good in this case. When two ensilage periods have a corn fodder period between them, it is fair to presume that the average of the first and last periods will fairly represent what the cow would have done during the middle period had she then been eating ensilage; and the same when an ensilage period comes between two corn fodder periods. Each of the three cows furnishes an example of each of these changes as appear below:

IN PASSING FROM ENSILAGE TO FODDER AND BACK.

Ration.	Period.	Betsy.		Topsy.		Period.	Dolly.	
		Total Water Cons'm'd	Total Milk Yield.	Total Water Cons'm'd	Total Milk Yield.		Total Water Cons'm'd	Total Milk Yield.
Corn Ensilage --	I	1140	394	973	356	I	1083	304
"	III	1126	329	1006	341	IV	898	253
Average --		1133	361	980	349		991	279
Corn Fod'r	II	1017	342	821	339	III	846	270
Shrinkage.		116	19	159	10		145	9
" %		10.4	5.7	16.	3.		14.6	8.2

IN PASSING FROM CORN FODDER TO CORN ENSILAGE AND BACK AGAIN.

Ration.	Period.	Betsy.		Topsy.		Period.	Dolly.	
		Total Water Cons'm'd	Total Milk Yield.	Total Water Cons'm'd	Total Milk Yield.		Total Water Cons'm'd	Total Milk Yield.
Corn Fod'r	II	1017	342	821	339	I	1029	307
"	IV	990	306	631	287	III	846	270
Average --		1003	324	726	313		938	289
CornEn'lge	III	1126	329	1006	341	II	1083	304
Gain-----		123	5	280	28		145	15
" %----		10.9	1.5	28.	8.2		13.3	5.2

In every case when there has been a decrease in milk flow there has been a decrease in the total amount of water taken into the system and every time there has been a gain in milk there has been an increase in the amount of water taken into the system. Which is cause and which is effect this experiment alone would not determine.

In all six cases less water is accompanied by less milk, though in three of these cases there is more dry matter eaten per day, and in three less dry matter. In the three cases where more dry matter was eaten, there was once more solids and more fat given, and twice less solids and less fat. In the three where less solids are consumed with less water, there is once a trifle more solids and more fat and twice less solids and less fat. In three cases where water consumed is not known, more dry matter in food produced in every case more solids and more fat.

These figures would seem to indicate that as cows get farther along in lactation they take less water into the system. It does not, however, follow that they consume less dry matter. In three cases we have had at the Station where cows have had a given ration and four months later been put back on the same ratlon, not changing in live weight, they have eaten almost exactly the same amount of fodder though giving 33 per cent less milk.

As the cows became farther along in lactation the amount of milk produced lessened, and by comparing one ensilage period with another and one fodder period with another, we can ascertain whether there was any corresponding change in the amount of water consumed.

	Ensilage Periods.		Corn Fodder Periods.		All Periods.	
	Total Water Consum'd.	Milk Produc'd.	Total Water Cons'd.	Milk Prod'd.	Total Water Con's.	Milk Pro'd.
Earlier Period.	3142	1061	2868	988	6010	2049
Periods 8 Weeks later.	2519	846	2467	863	4986	1709
Per cent of Shrinkage.	**19**	**20**	**14**	**13**	**17**	**16.6**

Thus as milk shrank, total water consumed shrank and in almost exactly the same proportion.

That this is not chance, but a characteristic of cows in milk will appear from a study of the experiments made during three years at the Wisconsin Experiment Station. In seven out of eight tests, the cows took more water into the system daily and gave more milk while eating ensilage than while on corn fodder and in the other case the amounts were equal, thus on the ration which produced the most milk they consumed the most water. When the cows returned at a later period to the same ration they had had earlier, they gave, of course, less milk and they took less water in three cases out of four. The average shrinkage in milk was eight per cent and they took ten per cent less water. These figures show that cows need to consume more water the more milk they give and that they will do so whether the food is succulent or dry.

In period II with water 39° and barn 46° there were 2.9 pounds of water drank for each pound of milk yielded. During period IV on the same feed with water 1° warmer and the barn 4° warmer the amount of milk yielded was considerably less, but the amount of water taken into the system was enough less so that the proportion of water and milk remained unchanged.

EFFECT ON MILK FLOW OF CORN FODDER AND CORN ENSILAGE.

The table already given shows that every time the cows changed from corn ensilage to corn fodder and back again to ensilage, the average of the amounts given during the two ensilage periods is larger than that given during the fodder period, and when the change was made from corn fodder to ensilage and back again to fodder, the ensilage proved superior to the fodder. In other words the ensilage yielded per day and per cow more milk than the corn fodder.

EFFECT ON QUALITY OF MILK OF CORN FODDER AND CORN ENSILAGE.

Our usual experience has been that the quality of the milk remains unchanged in passing from corn fodder to ensilage or from ensilage to fodder. In the present experiment quite a decided change was noted. In eight cases out of nine corn fodder produces milk with a larger per cent of solids than that given by corn ensilage, and in seven cases out of nine the milk also has a higher per cent of fat. In general, then, corn ensilage has given more milk of a poorer quality and corn fodder less milk of a richer quality. The average milk from corn ensilage contained 12.91 per cent total solids and 4.05 per cent fat, the average of corn fodder is 13.35 per cent solids and 4.28 per cent fat.

TOTAL AMOUNT OF PRODUCT YIELDED.

By uniting the figures referred to above we get the total amount of solids and of fat yielded per day and per cow on corn fodder and corn ensilage and they are found to differ but little. In five cases the ensilage produced more solids and fat than the corn fodder and in four cases it produced less.

The figures so far refer to the product per cow and per day. To get a full understanding of the experiment it will be necessary to consider the results obtained as a whole from the entire mass of fodder material.

There were 14,262 pounds of corn fodder fed from the stooks. The three experimental cows produced 4,897 pounds of milk while eating 9,089 pounds of corn fodder. At the same rate the whole of the corn fodder would have produced 7,688 pounds of milk. The same cows ate 14,266 pounds of the ensilage and produced 5,922 pounds of milk, or the equivalent of 8,525 pounds of milk for the whole 20,532 pounds of ensilage. This makes a total of 838 pounds of milk or 9½ per cent in favor of ensilage. Calculating in the same way for solids and fat the table below is obtained:

	Milk. Pounds.	Total Solids. Pounds.	Fat. Pounds.
The entire corn ensilage produced	8525	1099	345
The entire corn fodder produced	7688	1026	329
Gain due to ensilage	837	72	16
Gain per cent	9.5	7.1	4.6

If the last twelve days of each period are used as the basis for calculating the whole, the gain in favor of ensilage amounts to 6½ per cent of milk, 3 per cent of solids and 1 per cent of fat.

Still another way of arriving at results is to figure on the basis of dry matter, when these results are obtained:

	Milk. Pounds.	Total Solids. Pounds.	Fat. Pounds.
Corn ensilage produced for each pound of dry matter in experimental fodder	2.40	0.31	0.097
Corn fodder produced for each pound of dry matter in experimental fodder	2.18	0.29	0.093
Gain in favor of ensilage, per cent	9	6	4

The average of these three methods of figuring gives a gain in favor of ensilage of 8 per cent of milk, 5 per cent of solids and 3 per cent of fat.

The ensilage fed two cows twelve weeks each and one cow eight weeks with 30 per cent left or the equivalent of one cow 45.7 weeks. The corn fodder fed one cow twelve weeks and two cows eight weeks with 36 per cent left or the equivalent of one cow for 44 weeks, a gain therefore in favor of the ensilage of 1.7 weeks or 4 per cent.

It is interesting to note in this connection the experiments made at the Wisconsin Station during the same time as at ours, and with the same object in view, that is, the comparing of the relative feeding value of ensilage and of corn fodder from the same source. The general details of ensilaging and stocking were the same. The principal differences in the methods used were, that in Wisconsin the corn fodder was left in ordinary sized stooks in the field where it grew, while the corn fodder in Vermont was stooked near the barn in large stooks. In Wisconsin the cows made but one change during the winter from one feed to another. In Vermont they changed four times. The Wisconsin experiment was conducted on a larger scale then the one in Vermont. When we come to consider the results we find that the general conclusions very closely agree. In Wisconsin the ensilage lasted 5 per cent longer then the corn fodder; in Vermont it lasted 4 per cent longer. In Wisconsin ensilage produced 5 per cent more milk than corn fodder; in Vermont it produced 9½ per cent. In Wisconsin ensilage produced 6½ per cent more butter than corn fodder, in Vermont it produced 4 per cent. But not withstanding the very close agreement of the final results, the details of the two experiments are quite different in several particulars. In Wisconsin the milk given while eating ensilage, was slightly richer than that during the corn fodder periods, while in Vermont the milk given on corn fodder was decidedly richer than that on ensilage. The corn when harvested in Wisconsin was somewhat dryer than that in Vermont, having 1½ times as much dry matter in each 100 pounds. The loss of weight in silo was the same in both cases, viz. 18 per cent, but a larger proportion of this in Vermont was dry matter than in Wisconsin, the total loss of dry matter in the Vermont ensilage being 20 per cent while in Wisconsin it was only 10 per cent. The greatest difference between the two experiments lies in the history of the changes that occurred in the stooked corn fodder, and shows very plainly how much dryer the air of Wisconsin is than that of Vermont. The Vermont stooks lost 43 per cent of total weight, while the Wisconsin stooks lost 75 per cent. In Vermont 48 per cent of the water in the corn fodder dried out, and 90 per cent of that in Wisconsin, which is a trifle more even than is dried out from ordinary timothy hay in curing. The dry matter of the corn fodder lost 19 per cent of its weight in Vermont during curing, and 28 per cent in Wisconsin. The albuminoids in Vermont decreased 17 per cent and 34 per cent in Wisconsin. The Wisconsin ensilage became drier the longer it stood changing from 25 per cent dry matter to 28 per cent, an increase of one eighth, while the Vermont ensilage continually had a smaller percentage of dry matter, changing from 18.20 to 17.66 per cent dry matter, a decrease of one-thirtieth. There is an equally wide difference in the relative feeding value of the dry matter of the ensilage and corn fodder in the two experiments, the stooked fodder losing 18 per cent more dry matter than the ensilage, in Wisconsin, and a pound of this dry matter having 12 per cent higher feeding value than an equal weight of the dry matter of the ensilage, the extra loss in quantity being mostly recovered in weight of product. In Vermont the loss of dry matter in the two methods is nearly the same 20 per cent in ensilaging and 19 per cent in stooking. The loss of a buminoids is highest in the stooked so that we should expect from analyses that the dry matter in the corn fodder would have a lower feeding value than that of the ensilage, and in the feeding trial we find that a pound of dry matter in the ensilage produced about 9 per cent more milk than an equal amount in the corn fodder. We have then the two experiments, starting at the same point and reaching practically the same results, although the separate steps in the course are widely different.

Comparing two ensilage periods with the fodder period between or two fodder with the ensilage, as to amount produced by one pound of dry matter of the experimental fodder, we find that a pound of dry matter in ensilage produced more milk than a pound of dry matter of fodder in six cases out of nine, more solids in six cases out of nine, more fat in six cases out of nine.

The differences in amount of solids and fat are not large and are so small that they can almost be left out of account, and we can say that ensilage increased quantity of milk decidedly, but at the same time it decreased the quality of it just about enough to overbalance the increase in quantity, so that the final result is that there is but little difference between the amount of milk solids and milk fat produced by a pound of dry matter in the form of ensilage and in the form of stooked corn fodder.

The labor required in feeding was largely in favor of ensilage. It took nearly as much time and expense to bring the corn fodder to the barn and stook it, as it did to run the corn through the cutter into the silo, but it took several times as much labor and expense to bring the corn from the stooks into the barn and cut and feed it as it did to take the ensilage out of the silo. The cows seemed to like the ensilage a little better than they did the corn fodder, though they ate the corn fodder with a great deal of relish.

III. A COMPARISON OF CLOVER ENSILAGE AND CORN ENSILAGE FED TO MILCH COWS.

By J. L. HILLS.

Ten cows were fed eight days on corn ensilage the next eight on clover ensilage of very fine quality and then a third eight on corn ensilage. In passing from corn to clover five increased or held the same, five (three being strippers) decreased in milk yield; the ten as a whole dropped 0.8 per cent in yield. In passing from clover to corn three increased or held the same, seven (four being strippers) decreased in milk yield; the ten as a whole dropped 4 per cent in yield. Excluding two cows one a stripper and one not well during the second corn period, the other eight dropped 0.75 per cent in passing from corn to clover and 2.50 per cent in passing from clover back on to corn. These changes are not more than natural shrinkage will account for. All of the cows gave better quality of milk on the corn ensilage than on the clover ensilage, averaging 0.35 per cent more fat or about 8 per cent better. The test would indicate that so far as milk and butter yields were concerned, this clover ensilage did not do so well as did the corn ensilage.

IV. THE EFFECT OF CHANGE OF QUARTERS ON QUANTITY AND QUALITY OF MILK.

By J. L. HILLS.

On the morning of Oct. 30, the herd was milked for the last time at the old station farm, and then driven three and a half miles to their new quarters at the present farm. Composite samples were taken of the milks of seven cows for four milkings before and four after the change.

Results are summarized as follows:

	Lbs. of milk daily.	PER CENT OF				POUNDS OF			
		Total solids.	Fat.	Ca-sein.	Milk sugar and ash.	Total solids.	Fat.	Casein.	Milk sugar and ash.
Before change	138.88	12.95	4.40	3.20	5.35	17.980	6 116	4.439	7.425
After change	151.75	12.63	4.09	3.08	5.46	19.173	6.205	4.677	8.291
Increase or decrease	+12.87	— 0.32	—0.31	—0.12	+ 0.11	+ 1.193	+ 0.089	+ 0.238	+ 0.866
Per cent increase or decrease.	+ 9.3	— 2.5	—7.0	—3.8	+ 2.1	+ 6.6	+ 1.4	+ 5.4	+11.9

Not only was there a general increase in yield during the two days but each individual cow gave more at each milking than at the corresponding one before the change. Six out of seven gave a poorer quality after the change but one giving a higher fat percentage and but one a higher casein percentage.

The quantity gain in the aggregate was greater than the quality loss, so that six and a half per cent larger yield of milk ingredients followed the change.

Individually the same thing was noted with five cows, but in one case the fat fell 3 per cent, and in another, fat and casein 9 per cent and 3 per cent of the total quantity given. The result of the experiment is obscured somewhat by the facts that a change of feed occurred simultaneously with the change of barn and that the cows remained indoors instead of outdoors during the day time. Babcock* in a similar experiment on two cows, found "not only a falling off in the quantity of milk at the first milking, but a more decided falling off in the quality" which was "more than compensated by improvement on the following days, so that in the aggregate there appears no loss from change in place." The experiment here reported is in line with the latter but not the former result. It should be noted that except in the matter of the change, the new conditions, better feed, shelter, better cow stalls, same milkers, were more favorable than the old, whereas a change of quarters and surroundings is often apt to be for the worse, disturbing to a cow and detrimental to production. This is particularly true as regards fair tests of cows, yet, even there the individuality of the cow is seen since, as shown in Bulletin 22 of this Station, "some cows produced more at home amid their usual surroundings, while some seemed stimulated by excitement and nervousness and made a better showing at the fair grounds than they did at home."

V. ENSILAGING TURNIPS.

A small experimental silo was filled with cut turnips and heavily weighted. The material contained 9.50 per cent dry matter. The experiment was tried in mid-winter, with cold turnips and in a cold room. There was no appreciable rise in temperature and all went well for about two weeks when the mass gave way and fell in. There was too little dry matter, particularly of a fibrous nature, to hold together the mass. The result was expected and the moral is, *Don't.*

VI. MAKING CHEESE FROM DIFFERENT QUALITIES OF MILK.

By W. W. COOKE AND J. L. HILLS.

The belief has been lately gaining ground that paying for milk at cheese factories according to the butter fat it contains is the nearest correct of any way given, or at least the nearest correct of any practicable method yet proposed.

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*Sixth Annual Report Wis. Ex. Station, p. 57.

If it was true that casein in milk increases in the same ratio as fat there is no doubt that the view just mentioned would be correct, but this is not the rule, since when fat increases the casein increases much more slowly, hence milk containing 4 per cent of fat will not make one-third more cheese than milk containing 3 per cent of fat. In order to test this question by practice as well as by theory a test was recently carried out by this Station in making cheese from 3 per cent milk, 4 per cent milk and 5 per cent milk.

The first question to be decided was whether the fat could be saved as perfectly in rich milk as in poor. The test was made as follows:

On one day about 3,000 pounds of milk were used, just as it came to the factory, analyzing very closely to 4 per cent fat. The next day to about an equal amount of the milk was added about 1,000 pounds of fresh separator skimmilk, making the milk contain about 3 per cent of fat. The third day to the same amount of whole milk was added enough separator cream to bring the fat up to 5 per cent. This made the milk of the third day to contain 5 per cent of fat and only 3.20 per cent of casein, whereas according to average analyses milk containing 5 per cent of fat would commonly contain 3.75 per cent of casein. It would, therefore, be harder to work this milk on the third day without loss of fat than would ordinarily happen in the fall when the general run of milk contains 5 per cent of fat as delivered at the factory.

MANUFACTURE OF CHEESE.

Date.	Whole milk. lbs.	Skimmilk. lbs.	Cream. lbs.	Total milk. lbs.	Per cent of fat.	Green cheese. lbs.	Cured cheese. lbs.	Cheese to 100 lbs. milk lbs.	Cheese to 1 pound fat. lbs.
June 3	2784			2784	4.00	311	297	10.66	2.67
" 4	2724	916		3640	3.00	353	338	9.08	3.03
" 5	2488		200	2688	5.00	321	307	11.40	2.28

ANALYSIS OF CHEESE.

Date.	Water.	Fat.	Casein.	Salt and ash.	Undetermined
June 3.	35.38	32.50	23 91	3.73	4.48
" 4.	37.56	27.70	25.58	3.96	5.20
" 5.	34.62	37.52	20.19	3.71	3.96

LOSSES.

Date.	Fat in Milk. Per Cent.	Whey.		Drippings.		Total Fat lost for each 100 lbs. fat in milk.
		Fat. Per Cent.	Casein. Per Cent.	Fat. Per Cent.	Casein. Per Cent.	
June 3.	4.00	0.25	0.95	13.00	1.10	8
" 4.	3.00	0.17	0.95	3.00	1.60	5
" 5.	5.00	0.30	0.95	7.00	1.40	6

In the work of these three days there was a moderate amount of loss of casein in the whey. The casein in the whey was the same for the three days, that is 0.95 per cent.

It would probably be more exact to note that the word casein is here used as synonymous with albuminoids. If it is advisable to be more exact, we would say that the whole milk contained about 3.30 per cent of albuminoids of which 0.70 was albumen and the rest casein, and that in the process of cheese-making the casein went into the cheese and the albumen into the whey as 0.95 per cent of albuminoids. In other words one-fourth of all the albuminoids of the milk was lost in the whey, and three-fourths was accounted for in the cheese. This may seem a large proportion to lose to those who do not know that the albumen in the milk cannot be coagulated by the rennet, and hence is bound to be lost in the whey, no matter how thoroughly the cheese-maker understands his business. The whey of the first day contained 0.25 per cent of fat; the second day 0.17 and the third day 0.30. The drippings from the cheese during the pressing make the loss in fat more the first day than the other two days, the percentage being, first day 13 per cent fat: second 3 per cent fat, the third day 7 per cent, making a total loss the first day of 8.pounds of fat for each hundred pounds in the original milk; the second day of 5 pounds out of the hundred; and the third day of 6 pounds out of the hundred.

There is so little difference in the loss of fat and the loss of casein, that it is fair to presume that with care milk of either 3, 4 or 5 per cent can be made into cheese without much difference in the amount of fat loss. In other words, there is no necessity of wasting fat in the whey when making cheese from 5 per cent milk. It is only fair, however, to add that the curd from the 5 per cent milk was very tender, and if the cheese-maker had not understood his business and had not taken extra care there would surely have been a large loss of fat.

It will be noticed that the different milks make different amounts of cheese for each pound of fat in the milk, the poor milk making more and the richer milk less than the average.

If these cheeses were all sold at the same price, and each patron was paid according to the amount of butter fat contained in the milk, the 5 per cent man would get more than his proportionate share and the 3 per cent man would lose some of the money that was rightfully his due.

There is, however, another important question which arises at this point, namely, will the cheese made from these three qualities of milk sell on the general market for the same price. This point was quite thoroughly studied in the test above described.

The cheeses made from these three qualities of milk were carefully cured in the same room, labelled 1, 2 and 3, and sent to one of the best commission houses in Boston, with the following letter:

"By express to-day we send you three cheeses, marked 1, 2 and 3. They are from different methods of manufacture, in some of our experimental work. Will you please have your expert sample them and score them on their relative quality and also state the price at which such cheese sells at the present time in the Boston market.

After doing this, will you please call in the expert from one of the leading commission houses, and have him go through the same performance, and without knowing the scoring or the prices fixed by your man. Please send me the prices and scores of both men."

The reply received from them is as follows: (No. 1 being the 4 per cent milk; No. 2, the 3 per cent; and No. 3 the 5 per cent.)

" After a careful examination ourselves, we called in three good judges and we found the unanimous judgment of the four, that the cheese marked No. 2 is the poorest quality of the three boxes. We should consider the value of this cheese at .07¼ on this market, and the other three marked at 7½. We, and one other, considered the cheese marked No. 1, the best, and two out of the three that examined the cheese, outside of ourselves, called No. 3 the best. There is no practical difference in the value between No. 1 and No. 3, which would be on this market about 8¼ cents per pound.

We thank you for the compliment in sending us the cheese, and have tried to give the matter a thorough trial, and trust same will be satisfactory to you."

It will be noticed that all the four judges considered the 3 per cent cheese the poorest, but what is still more worthy of notice, the four men were equally divided as to whether the 4 per cent or the 5 per cent cheese was the best, but all four agree that both these cheeses would sell on the Boston market at the same price.

Analysis showed that the 5 per cent cheese contained 37.5 per cent butter fat, and that the 4 per cent contained 32.5 per cent. Here is a difference of 1-6 in the amount of fat in the two cheeses,and yet no preference is given to the richer cheese by these four experts. But was there enough more cheese made from the 5 per cent milk than from the 4 per cent to make up for the extra amount of fat contained in the milk? The difference in this particular case was surprisingly small. Analysis showed the reason to be that the rich cheese was very much drier than the cheese from 4 per cent milk, the extra fat seeming to have taken the place of so much water. At the price mentioned, 8¼ cents a pound, the 4 per cent milk would have been worth 92 cents a hundred, while the 5 per cent milk only 95 cents a hundred, or 23 cents a pound for the butter fat in the cheese from 4 per cent milk, and only 19 cents a pound for that from 5 per cent milk.

If the fat in the milk would have brought more than 19 cents a pound made into butter, there was a waste in using it to make cheese rather than butter.

With the 3 and 4 per cent milk we get some very interesting figures. Counting the cheese from the 4 per cent milk at 8¼ cents a pound, and that from the 3 per cent milk at 7⅜ cents, which is the average between the two prices mentioned by the experts, gives in each case exactly the same amount, that is 23 cents per pound for the butter fat contained in the cheese.

The figures show that in this test, cheese made from 3 per cent and 4 per cent milk was valued on the Boston market exactly in proportion to the amount of butter fat contained in the milk from which it was made, but that in using the 5 per cent milk for cheese making there was a loss from what would have been obtained had the milk been made into butter.

In October three more tests were made yielding the following figures:

Date.	Total Milk Used. lbs.	Cured Cheese Made. lbs.	Fat in Milk. %	Casein in Milk. %	Cheese made for each 100 pounds of Milk. lbs.	Cheese made for each pound of Fat in Milk. lbs.
Oct. 20	3904	434	4.27	3.53	11.13	2.56
" 21	3829	432	4.31	3.59	11.28	2.62
" 22	3637	432	4.40	3.67	11.88	2.70
Total	11370	1298				
Average	....	....	4.33	3.60	11.40	2.63

Hence our work may be summarized as follows:

Fat in Milk. %	Cheese made for each 100 pounds of Milk. lbs.	Cheese made for each pound of Fat in Milk. lbs.
3.00	9.08	3.03
4.00	10.66	2.62
4.33	11.40	2.63
5.00	11.40*	2.28

*This milk was artificial and had less than the natural proportion of casein.

Since these tests were made tests have been reported from other Stations bearing on the same question. A late bulletin (New York Agricultrual Experiment Station, Geneva, N. Y., Bulletin No. 37, New Series. November 1891, p. 699-700) from the Station at Geneva contains the figures of quite an extended series of experiments with milks of different richness, in which they found that milk containing varying per cents of fat made the following amounts of cheese:

Number of Experiment.	Fat in Milk. Per Cent.	Casein in Milk. Per Cent.	Cheese made for each 100 pounds milk. Lbs.	Cheese made for each pound of fat in milk. Lbs.
1	2.35	3.34	9.05	3.85
2	3.01	2.81	8.86	2.94
3	3.88	3.45	10.11	2.60
4	3.96	3.81	11.25	2.84
5	4.70	3.91	11.07	2.35
6	4.73	3.53	12.12	2.56
7	4.80	3.24	11.12	2.32
8	6.49	3.37	12.52	1.93
9	3.70		9.73	2.63

The work of the Minnesota Station (Bulletin No. 19, March 1892, p. 20-21) furnishes the following averages.

Per Cent of Fat in Milk.	Pounds of green cheese to each 100 pounds of milk.	Pounds of cured cheese* to each 100 pounds of milk.
3.60	9.29	9.20
4.00	10.77	10.67
5.05	11.64	11.54

*Calculated on basis of 10¾ pounds cured cheese for 4.00 per cent milk.

Prof. J. W. Robertson of Canada makes the statement (Hoard's Dairyman, Dec. 25, 1891, p. 1896) that between 3 and 4 per cent each 2-10 of a per cent increase in fat makes 3-10 of a pound increase in cheese for each hundred pounds of milk, and raises the market value of that cheese ⅛ of a cent a pound. The general average of all these figures shows that 3 per cent milk makes on the average 9 pounds of cheese, and 4 per cent milk 10⅝ pounds; and that if the cheese made from the 3 per cent milk is worth 8 cents a pound, that from the 4 per cent milk will be worth 8¾ cents, that is, if the 3 per cent milk makes 9 pounds of cheese worth 8 cents a pound thus making the milk worth 72 cents a hundred, then 4 per cent milk will make 10⅝ pounds worth 8¾ cents a pound, making the whole milk worth 93 cents a hundred. But 72 cents is almost exactly ¾ of 93 cents, so that the market value of the cheese made from the two qualities of milk is almost exactly proportional to the amount of butter fat these milks contain. These rules will not hold for milk above four per cent. It is not true the five per cent milk will make a pound and a half more cheese to the hundred than four per cent milk. On the contrary the figures just given show that it will scarcely make a pound more owing to the greater dryness of the cheese made from rich milk, and moreover our American markets will not pay any more for the extra rich cheese than for the moderately rich. Therefore rich milk, that containing much over four per cent fat can be more profitably made into butter than into cheese. As a conclusion then from the data that have thus far become available, it can be said that with milks varying from 3 to 4 per cent paying for the milk according to the butter fat it contains, gives probably exact justice, while for milks under 3 per cent or over 4 per cent the agreement is not so close, and a great deal would depend on the skill of the cheese maker, and the market to which the cheese was sent.

It should not be taken that the foregoing calls into question the accuracy of the method outlined in our Bulletin 21 for the method of payment at cheese factories. That method is applicable to milks of all grades, and is correct, but at the same time it is more cumbersome than paying for the milk according to the per cent of fat alone that it contains. And the latter method as we have seen gives substantially correct results.

VII. LOSSES IN CHEESE MAKING.

Mechanical losses of fat have been found to occur in butter making "due to the greater viscosity of cream as compared with skimmilk, causing it to stick to pails, churns, butter workers, etc., and so bring about many minute losses which count up heavily in per cent of entire fat present (entire fat equal 100 per cent) on small batches of milk, but almost disappear calculated on the same basis when large quantities are used." *

Series of tests lasting three days were made in October at a cheese factory in the northern part of the State to determine if there were similar losses in fat and other milk ingredients in cheese making. Each day samples of each patron's delivery were taken and united into a single compos-

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*Fourth Annual Report Vermont Experiment Station, p. 93.

ite sample, the aliquots being proportioned to the deliveries. A sample was also taken from the vat just before the rennet was added. Duplicate samples of whey, curd-sink whey, and of curd, and triplicate samples of the drippings from the cheese presses were taken. Two green cheeses from each day's make were chosen, one analyzed at once, the other six weeks later when ready for market. Analyses were made of each sample in duplicate or triplicate and from each cheese duplicate samples were taken by cutting two slices entirely across the cheese and similarly analyzed. Weights of whole milks, whey, curd-sink whey, cheese-press drips, green and ripe cheese, salt, rennet, cheese caps, etc., were made and evaporations determined both at the factory and in the preparation of cheese for analysis; 3,905, 3,829 and 3,645 pounds of milk were used, making 434¼, 432 and 431½ pounds of ripe cheese or a pound of cheese to 8.99, 8.86 and 8.45 pounds of milk. On the third day a wetter cheese was made and hence the increased yield. It was found to contain two per cent more water than the cheese of the day before. The stirred curd process was used, and no more than ordinary care used to guard against mechanical loss.

We possess then data showing how much of each ingredient entered the vat and where it all went to. The following table gives the results and summarizes nearly four hundred laboratory determinations.

		POUNDS OF					
	Water	Total solids exclusive of salt.	Fat.	Casein and album'n	Milk sugar and lactic acid.	Ash.	Salt.
First day.							
In whole milk	3382.5	522.49	166.74	137.85	186.66	31.24	9.10
In cheese & waste pr'd's	3370.1	519.88	167.00	141.08	180.37	31.42	8.90
Gain or loss	—12.4	—2.61	+ 0.26	+ 3.23	—6.29	+ 0.18	—0.20
Per cent gain or loss	—0.37	—0.50	+ 0.16	+ 2.34	—3.37	+ 0.57	—2.20
Second day.							
In whole milk	3313.2	515.77	165.03	137.46	182.64	30.63	8.90
In cheese & waste pr'd's	3270.8	503.77	163.60	137.85	170.99	31.32	8.05
Gain or loss	—42.4	—12.00	—1.43	+ 0.39	-11.65	+ 0.69	—0.85
Per cent gain or loss	—1.28	— 2.33	—0.87	+ 0.28	—6.38	+ 2.25	—9.55
Third day.							
In whole milk	3153.7	491.35	160.38	133.77	168.03	29.16	8.50
In cheese & waste pr'd's	3151.8	495.15	164.10	130.72	170.18	30.16	7.94
Gain or loss	— 1.9	+ 3.80	+ 3.72	—3.05	+ 2.15	+ 1.00	—0.56
Per cent gain or loss	—0.06	+ 0.77	+ 2.32	—2.28	+ 1.28	+ 3.42	—6.60
Average.							
In whole milk	3283.1	509.87	164.05	136.36	179.11	30.37	8.83
In cheese & waste pr'd's	3264.2	506.26	164.90	136 55	173.84	30.96	8.29
Losses	—18.8	—3.61	+ 0.85	+ 0.19	—6.27	+ 0.59	—0.54
Per cent loss	—0.57	—0.71	+ 0.52	+ 0.14	—3.50	+ 1.90	—6.10

The milks contained 13.38, 13.47 and 13.48 per cent total solids ; 4.37, 4.31 and 4.40 per cent fat ; 3.53, 3.59 and 3.68 per cent casein ; the six wheys from 0.40 to 0.62 per cent fat averaging 0.46 per cent and the cheese press drips 1.40, 1.00 and 1.06 per cent fat.

The green cheeses contained from 38.19 to 40.29 per cent water ; from 31.77 to 32.71 per cent fat ; from 22.26 to 23.38 per cent casein, and the ripe cheese from 34.27 to 36.89 per cent water ; from 33.96 to 34.83 per cent fat; and from 23.72 to 24.41 per cent casein.

Before considering the records as a whole a few points may be noted The evaporation was less than was anticipated, much less than undoubtedly takes place in the summer. The constant and large percentage loss of salt may be explained by the fact that the salt credited to the whole milk being that added to the curd, was assumed to be chemically pure and water free, both of which assumptions were of course incorrect, while that credited to the cheese and its products is the result of analysis. As ordinarily kept at creameries and cheese factories, salt may often contain water enough to account for the discrepancy.

The ash was determined only in the cheese and curds and assumed to be 0.80 per cent in the milk (the herds were composed of strippers and 0.80 per cent is probably nearer truth on such cows than 0.75 per cent the usual average) and 0.60 per cent in the whey. Milk sugar is calculated by difference. These assumptions and calculations tend to make percentage gains and losses on these commercially valueless materials wider than on the other ingredients.

The tabulation shows but slight mechanical losses expressed in percentages of the total ingredients present, and an apparent gain is as frequent as a loss. All of these gains and losses are well within the limits of the admissable errors of chemical analysis. Each ingredient, however, being determined at least twice in duplicate samples this source of error is lessened, yet to it and to the unavoidable errors of sampling we may justly credit the gains.

Water is always closely accounted for, solids and fat twice and casein once, while solids and fat once and casein twice are out by almost identical percentages. Van Slyke* found as a rule little mechanical loss of fat and casein on amounts of milk from 240 to 340 pounds making from 23.5 to 46.7 pounds of cheese ranging from 0 to —6.34 per cent on the fat, and from + 3.4 to — 8.03 per cent on the casein, the ingredients used and recorded checking within close limits in most cases.

It is seldom that so small quantities of milk are handled in cheese making as is often the case in butter making, except in the manufacture of fancy brands. Probably the proportional or percentage losses on smaller quantities would increase as they do in butter making, but not to so large an extent. The objects of the two processes are opposite. One separates and handles viscid products, cream and butter, the other prevents this separation and unites butter and casein together in a less viscid body than either cream or butter. The more viscid materials of butter making must be handled four times in separating or creaming, ripening, churning and working, while in cheese making the milk ingredients pass through but three pieces of apparatus, vat, curd sink or mill, and press. The nature of the products and the method of handling them favors greater mechanical loss in butter making than in cheese making, and it may be quite surely said that *there is little or no mechanical losses of any of the milk ingredients in cheese making by the stirred curd process.*

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*Bull, No. 37. New York Exp. Stat.

The losses of fat in the wheys were above the average. Considering 21 per cent of the nitrogen solids to be albumen and that all the albumen passed into the whey, an assumption which is nearly true, the following per cents of total fat and casein present in milk were not in the waste products, and, consequently, assuming no mechanical loss, were present in the green cheese.

Amounts of materials saved in the cheese for each 100 pounds contained in the original whole milk :

	Fat.	Casein.
First Day	90.8	96.6
Second "	91.5	97.0
Third "	89.2	97.3
Average	90.5	97.0

Had the same amount of milk been made into butter with 0.20 per cent fat in the skimmilk and 0.50 per cent in the buttermilk, both good average separator creamery work, about 94 per cent of the fat would have been available for butter. The average of thirty consecutive days work on from 6333 to 9689 pounds milk at the Shelburne creamery was 92.5 per cent of the butter fat present available for butter.

The cheese press drips were less rich than had been anticipated. A large amount of fat may be lost here particularly in warm weather. These tests seem to indicate that under ordinary conditions little if any mechanical losses need occur in cheese making.

DISTRIBUTION OF INGREDIENTS IN CHEESE MAKING.

The amount of the fat and casein that go into the cheese have already been given. The table below goes more into detail and shows not only what is saved in the cheese, but also what is lost and where it is lost:

APPROXIMATE AVERAGE DISTRIBUTION OF INGREDIENTS IN CHEESE MAKING.

	Whey.	Cheese Press Drips.	Cheese.
Total Solids	449	0.9	54.2
Fat	9	0.4	90.6
Casein	22.	0.6	77.4
Milk Sugar	93.5	1.5	5
Ash	63	1	36
Salt	2	23	75

The above were obtained from the work at Hinesburgh, Oct. 20–22, by calculating the percentage distribution of each ingredient each day, adding, dividing by three and apportioning the mechanical losses or gains according to relative amounts.

CHANGES IN THE RIPENING OF CHEESE.

The cheeses were analyzed both green and ripe in order to note the losses in ripening. The Burlington market demands a mild flavored, lightly ripened cheese and these cheeses were considered marketable in six weeks. The analyses of each calculated into the pounds of ingredients, are as follows:

	POUNDS OF						
	Water	Total solids exclusive of salt.	Fat.	Casein.	Milk sugar, lactic acid etc.	Ash.	Salt.
First Day, Green	178.14	278.97	151.28	108.13	8.74	10.82	6 89
Ripe	148.82	277.70	151.25	106.00	13.11	7.34	7.73
Losses	—29.32	—1.27	—0.03	—2.13	+ 4.37	– 3.48	+ 0.84
Second Day, Green	184.46	271.56	149.16	105.41	5.57	11.42	5.98
Ripe	151.62	272.63	146.71	104.55	13.95	7.43	7.95
Losses	—32.84	+1.07	—2.45	—0.87	+ 8.38	– 3.99	+ 1.97
Third Day, Green	187.03	269.17	146.30	102.51	9.35	11.01	5.80
Ripe	159.04	264.65	147.57	102.41	6.86	7.81	7.81
Losses	—27.99	—4.52	+ 1.27	—0.10	—2.49	– 3.20	+ 2.01
Average, Green	183.21	273.23	148.91	105.35	7.89	11.08	6.22
Ripe	153.16	271.66	148.51	104.32	11.31	7.53	7.86
Losses	—30.05	—1.51	—0.40	—1.03	+ 3.42	– 3.55	+ 1.64

The changes which occur during cheese ripening are not well understood but seem to be continuous loss of water, development of gas from decomposition with formation of fatty acids and ammonia, and their compounds, together with the slow change of casein into a soluble condition. VanSlyke in the work already quoted found in five weeks ripening mechanical losses of fat while the cheeses were curing due to the oozing out of the fat, no loss of casein, and a tendency of the soluble nitrogen compounds to increase. He also found from 6.58 to 9.30 pounds loss of water to each 100 pounds cheese.

In the above table the water losses range from 6.03 to 7.11 pounds for each 100 pounds of green cheese. This seems to have been the only appreciable loss or change that is explainable. The constant apparent loss of ash and gain in salt is remarkable and at present we can offer no explanation. Mechanical losses of fat oozing on the rack probably occurred to a slight extent. Casein seems to have dropped a little in every case, possibly a slight change in composition.

The cheeses though called ripe were in reality but slightly cured late in the fall and were very mild and moist so that they were not favorable for the study of changes in ripening, nor did the pressure of other work admit of further analytical work.

The tests may be considered as indicating *that during the first month the main changes in the ripening cheese is a loss of moisture, a possible mechanical loss of fat, and a slight loss in casein.*

VIII. CREAMING OF MILK IN COLD SETTING.

By W. W. COOKE.

In our work on the creaming of milk by cold deep setting, we had several times obtained a large amount of fat in the skimmilk, under conditions where we had expected to obtain very thin skimmilk. It was judged that the trouble lay in the skimming of the cans, the work being done so rapidly as to draw some of the fat down into the skimmilk. To see whether this was the reason a large number of cans were skimmed, the skimmilk being drawn off very slowly, and samples taken of the first part, the middle and from the skimmilk that lay close under the cream.

In the first test that was made the milk was drawn out very slowly. The first pint tested 0.45, the bulk of the skimmilk 0.80, from 4 spaces to 2 spaces 0.90, and from 2 spaces down to within a few tablespoonfuls of the cream 0.85, thus showing no practical difference between the bulk of the skimmilk and that next to the cream. In several cases besides this we found the first pint to test some less than the rest of the skimmilk, which we judged to be due to some water having leaked into the can through the valve at the bottom, the cans being submerged, and thus under considerable pressure. In another case we obtained for the first pint 0.25 per cent of fat, from this to 2 spaces 0.35, and from 2 spaces to cream 0.35.

When the statement is made that the skimmilk was drawn down to the cream, it means so that there is almost no skimmilk left, the bottom of the Cooley can being so slanting as to allow the skimmilk to be drawn very completely. We afterwards tested to see whether in drawing off the milk fast a current would be formed which would suck the cream in, making the last skimmilk test higher than the middle.

The milk from Jersey cows was set in cold water for 24 hours and skimmed through a syphon set so as to draw out a full stream of skimmilk all of the time, the samples being caught without stopping the flow of the milk. First pint 0.30, middle 0.35, 6 spaces to 4 spaces 0.30, 4 spaces to 1 space 0.35. The mixed milk of the herd was set in cold setting and a pipette put through the cream into the skimmilk below, the finger being kept over the top so as to prevent the cream from entering. The little that was thought to have entered was blown out and then the pipette filled with skimmilk from about a quarter of an inch below the cream line. This tested 0.40 per cent fat. The skimmilk was then drawn from the can as usual, but very slowly, and the middle tested 0.30, and from 4 spaces to 2 spaces 0.20. The same was repeated on another can and the skimmilk drawn off rapidly; pipette sample 0.50, middle 0.40, 4 spaces to 2 spaces 0.40.

In all of these tests the bottom line on the glass is considerdd to be 2 spaces from the cream, thus using the word spaces with a different meaning from that which is ordinarily used and which is employed in the bulletins of other Stations, which do not take account of the blank part of the glass below the spaces, so that when it is said we skim to within 4 spaces we are as near to the cream as are others who say they skim to within 2 spaces.

The table below gives the result of sixteen tests:

PER CENT OF FAT IN SKIMMILK WHEN TAKEN FROM DIFFERENT PARTS OF THE CAN.

First.	Middle.	6—4	4—2	2—0	3—1	Pipette	
0.45	0.80		0.90	0.85			Slow.
0.25	0.25			0.30			
0.30	0.30			0.40			
	1.25		1.20	1.30			
	0.38		0.65	0.70			
0.30	0.35	0.30			0.25		Fast.
	0.40		0.60				
	0.30		0.20			0.40	
	0.40		0.40			0.50	
	0.65			0.80			
	0.39			0.43			
	0.20		0.20				
	0.55			0.70			
	0.33				0.50		
	1.00			1.08			
	0.60			0.87			

It will be noted that there is practically no difference between the average and that drawn between 4 spaces and 2 spaces, that is drawing off the skimmilk down to the last line on the glass slide on the Cooly can, and this seems to be true whether the skimmilk is drawn off fast or slowly. In the last half of this test the skimmings were done with moderate rapidity—about as a careful skimmer would naturally handle the milk. The tests from two spaces to the cream are naturally higher than the other tests, and yet the difference is not great.

Enough figures have been accumulated to show that after the milk stands in a can 24 hours, in cold water, the skimmilk is alike in composition from the bottom to within a very short distance of the cream, and that even this small amount of skimmilk is but a trifle richer than the bulk of it.

It is evident from these figures that if the skimming is done with care, it is safe to skim down very close to the cream. From the figures we have obtained we have become convinced that the average per cent of fat in the skimmilk, as it stands in the can for 24 hours is within a very few hundredths of one per cent of the per cent of fat in the middle of the skimmilk. It would be more accurate to draw off some of the skimmilk and catch the sample while the middle of the skimmilk was running out than to run the risk of drawing any cream out the upper end or taking that mixed with water at the bottom, although this is practically contrary to statements that have been recently published by others on this subject.

IX. CREAM RAISING BY DILUTION.

By W. W. COOKE.

For several years it has been claimed that adding water to milk helped the cream to rise. This question has been carefully investigated by several of the Stations and the facts of the case quite thoroughly determined. This Station has made a very large number of tests, some of which have been published. It is hardly necessary to publish the long list of those that have given negative results. It is sufficient to say that diluting for any form of *shallow* setting has not been successful. No better results have been obtained when cold water was added to the milk for deep setting.

The only form of dilution that has succeeded is the addition of hot water to milk for deep setting. Our late experiments have been directed to determining when this can be done to advantage. During the winter time, water at 45° or lower can be obtained without the use of ice and at such times diluting is not needed. But in this State there are large numbers of farmers who continue the use of deep setting without ice through the summer time after the water has become warmer than 55°. The figures below are commended to their attention. The figures are most of them averages of several tests.

	Set at 42° undiluted.	Set at 42° diluted with ¼ of water at 135°.	Set at 55° undiluted.	Set at 55° diluted with ⅓ of water at 130°.	Set at 60° undiluted.	Set at 60° diluted with ¼ of water at 135°.
Fresh Cows	0.23	0.20	0.60	0.28	0.60	0.44
Strippers	0.63	0.74	0.63	0.70	1.00	0.73
Fresh Cows	0.30				0.80	0.38
Strippers	0.40	0.75			1.25	0.60
Average	**0.39**				**0.91**	**0.54**

As a result of these experiments in diluting milk it is shown that with milk from cows freshly calved there is a decided benefit in diluting milk with from a quarter to one-fifth its weight of water at 130° to 135°, whether it is to be in water at 55° or 60° over setting in water at the same temperature undiluted. In one instance there has been a gain in setting such milk diluted in cold water over the same undiluted. With cows far along in lactation there seems to be little if any difference in the results obtained whether the milk was set cold undiluted, cold diluted, or set at 55° undiluted. When set at 60° undiluted there was a large loss over what was obtained by setting at the same temperature diluted.

In fact the statement can be made that there has been gain in every case by diluting the milk when it was to be set at 60°, but at 55° there was gain with cows fresh in milk and no gain with those far advanced in lactation.

X. THE COMPOSITION, CREAMING AND CHURNING OF COLOSTRUM.

By J. L. HILLS.

Immediately after a birth and preceeding the true milk flow, the mammary glands of the mother secrete an acrid, viscid, yellowish fluid, heavier than milk and of alkaline reaction, which is called the colostrum.

The first fluid given is most markedly colostral in character, the second and succeeding ones less so, until by the sixth to the tenth milking, the true milk flow is usually considered established and the product used.

Colostrum differs from milk, mainly in containing less casein and sugar, more ash, many times more albumen, and in containing peculiar granules known as "colostrum corpuscles"; its office is purgative, enabling the offspring to rid itself of the accumulations of the foetal bowel.

In the summer of 1890 tests were made at this Station; first, to compare the chemical compositions of colostrum and milk, and of the first four or more colostral milkings, with a view of judging when it is fit to use; second, to compare the creaming and churning of colostrum and milk; third, to compare colostral butter with ordinary butter. During the past six months a few more analyses bearing on the first point have been made. Two grade and one fullblood Jersey, were used in the test. A full blood Devon was also scheduled for use but she died of milk fever.

The work was carried out as follows: The first four colostrums after sampling were set separately is deep cold or in ordinary shallow setting, skimmed in 24-48 hours, skim-milks sampled and the creams separately churned in a Frank's Wonder Churn; the butters were well washed and without salting prepared for analysis. Three weeks later a similar course was followed for four milkings with each cow.

The following table gives the average composition of the colostrums of the three cows, analyses being grouped by milkings, and the average composition of milk three weeks later. The colostrum analyses are the means of three samples, and each milk, the mean of twelve. None of these first colostrums analyse so high as they would have done had the cow been milked immediately after calving.

Average Analyses.	Specific Gravity.	Total Solids. Actual	Total Solids. Calculated.	Fat.	Casein and Albumen.	Milk Sugar.	Ash.
First Milking Colostr'm	1.0533	19.37	17.96	3.86	11.44	2.40	1.67
Second " "	1.0415	14.33	13.88	2.92	6.49	3.60	1.33
Third " "	1.0380	12.98	12.60	2.58	5.01	4.16	1.23
Fourth " "	1.0364	13.92	13.55	3.71	4.71	4.28	1.24
Milk (three weeks after calving)	1.0330	13.52	13.77	4.60	3.34	5.00	0.58

German analyses give as a maximum of twenty-two cows, milked immediately after calving, specific gravity 1.079, total solids 32.57, fat 4.65. casein 7.14, albumen 20.21, milk sugar 3.83, ash 2.31.

In this connection it may be of interest to call attention to the remarkable colostral milk given by a Devon cow a few hours before death. A little more than a quart was given which *creamed with the cream at the bottom and the skim-milk at the top*, the cream line being perfectly distinct. Careful pipetting separated cream and skim-milk and each was analysed with the following results ;

	Sp. gr.	Total Solids.	Fat.	Casein and albumen.	Milk Sugar and Ash.
Cream	1.0215	11.30	4.38	4.93	1.99
Skim-milk	1.0201	5.95	0.14	3.96	1.85

An unsuccessful attempt was made to churn this cream.

Some twenty-five further analyses of colostrums ranging from the first to the ninth milkings of four other cows, (three Jersey, one Holstein) show wide discrepancy between the solids by analysis and by calculation in the first three milkings and close agreement from the fourth on, indicating that the character of the flow was getting to be that of normal milk. Fat percentages were exceedingly irregular, 2.58 and 6.37 per cent being found in third colostrums. Oddly, the former was from a Jersey, the latter from a Holstein cow.

The points to notice are the higher specific gravity, larger percent of total solids, ash and nitrogenous bodies, and smaller per cent of milk sugar in the colostrums than in the milk ; the rapidity with which the fluid becomes more like milk, as shown by analysis, and by the closer agreement of actual and calculated total solids. The calculation of total solids depends upon the correct determination of specific gravity and fat and its results are more or less close to actual total solids as the milk is more nearly normal.

These data would indicate that the fifth and succeeding colostral milks of the average single cow may be safely used in the mixed milk of a medium sized herd, the eighth and succeeding ones in a small herd.

On general principles a viscid milk creams poorly, and consequently the colostrums were diluted before setting. This was found unnecessary in the case of colostrum and in fact the best creaming was undiluted in shallow setting.

Averaging analyses in the same manner as in the preceding table and correcting for dilution, we have :

	Total Solids.	Fat.	Casein and Albumen.	Milk Sugar and Ash.	Creaming.
Skim Milk, First, Colostrum	15.18	0.25	9.64	5.29	93.5
" Second "	11.50	0.24	6.09	5.18	91.8
" Third "	10.63	0.23	5.07	5.34	91.1
" Fourth "	10.88	0.39	4.95	5.54	89.1
Average anal. Skim Milk (3 weeks after calving)....	9.14	0.39	3.30	5.45	91.5

The creaming of the colostrums was actually better than that of the milk three weeks later. The difference is not great, however, but is evidence of the ability of the colostrum to cream.

The "Wonder" churn was used because the small amounts of cream would have been lost in an ordinary churn. All the butters, colostral and milk, came within five or six minutes, and most of them within two minutes, the churnings being made sweet. The colostrum creams as a whole took longer to churn than those from milk. No analyses of buttermilks were made as this churn in our hands has always left large amounts of fat in the butter milk.

The colostrum butters were vividly yellow and the strong odor of the fluid remained in them in spite of thorough washing. They had the acrid disagreeable colostrum taste and became rancid much more rapidly than did the milk butters.

The average analyses of colostrum and milk butters are:

	Colostrum Butter.	Milk Butter.
Water	14.15 per cent.	15.21 per cent.
Curd	0.87 "	0.51 "
Fat	84.98 "	84.28 "

The main difference is in the curd, the highly nitrogenous colostrum leaving more in the butter than did the milk.

The butter fats, twenty-four in number, were analyzed for melting point, iodine absorption and volatile acids, and results are summarized in the following table:

	Melting Point. C°	Iodine No.	Vol. Acids. C. C. $\frac{N}{2}$ alkali to 5 grams fat.
1st Colostrum	39.6	36.8	22.6
2d "	38.6	35.7	24.9
3d "	37.8	36.1	31.1
4th "	38.9	36.3	29.9
Average	38.7	36.2	27.1
Milk	37.4	37.5	28.4

Individual results are often irregular, and frequently the amounts of butter fat available were too little for satisfactory analysis, some determinations being entirely omitted. This accounts for some of the irregularities in the volatile acid results. The melting point of colostral fat appears to be higher, and the iodine absorption number and volatile acids lower than those of true butter fat.

The differences are not so marked as those obtained by Engling and by Nelson* on melting point and volatile acids, but are in the same direction.

The higher melting point and lower iodine absorption number bear each other out in the indication that colostrum butter contains less olein than ordinary butter.

*Zeit Anal. Chem. 28. 175.

In brief, chemical analysis bears out the usual farm practice in the use of milk on the third or fourth day from calving; colostrum creams and churns readily; colostrum butter is of disagreeable hue and taste and becomes rancid rapidly; and its fat melts at a higher temperature, absorbs less iodine and contains less volatile fatty acids, than does true butter fat.

XI. A NEW METHOD OF TESTING COWS.

By W. W. COOKE.

There is at the present time a great demand for some method of handling milk and producing butter that can be relied upon to do justice to the cow, that is, a method that shall show the cow to her best advantage and at the same time be perfectly fair. This Station has been at work on the perfecting of such a method and we think the one outlined below fulfills quite perfectly the requisites, and will also be found widely useful in the testing of individual cows on the farms of breeders.

The possible methods that can be used are the shallow setting, cold deep setting, and the separator. The first two of these methods we can leave out of account, for in addition to other disadvantages, it is a well known fact that they are not perfect skimmers nor is there certainty in their work. It has become a well known fact that when cows are well along in lactation neither of these methods gives good results, large amounts of fat being left in the skimmilk. Dairymen are agreed that to get certainly good results under all conditions, with all feeds and all breeds, it is necessary to use some form of the centrifugal separator.

The problem of handling the milk of single cows is quite a different problem from that which confronts the creamery man handling several thousand pounds of milk a day. The peculiarity of the work is the small quantity of milk handled. By whatever method and in whatever quantity milk is handled, there are always some losses from the cream sticking to the utensils used. In general, mechanical loss might be taken to mean the difference between the fat in the original whole milk and that recovered in the skimmilk, buttermilk and butter. Theoretically these two should agree and if they do not and the analyses have been correctly made then the difference represents the fat which has disappeared from sight, which has been mechanically lost during the operation of handling the milk. This subject has been quite thoroughly treated in the report of this Station for 1890, p. 92, and figures and arguments need not be repeated here. It is only sufficient to say that where small amounts of milk were used, with great care in handling, about 5 per cent of the fat was lost and appeared neither in the skimmilk, buttermilk or butter, and where small quantities were used with ordinary care this loss increased on the average in 31 tests to 8 per cent, and in individual cases even higher.

In making these tests we used the De Laval Baby Separator, No. 2, of the Alpha pattern. When this was used under ordinary conditions it was found to handle small quantities of milk and produce a skimmilk just as thin as would be obtained if a large quantity of milk was run through, but when the cream was tested it was found that a large amount of fat of the whole milk had not been recovered in the cream. The bowl of this size of separator holds just two pounds of milk, and of course it is full of milk when the machine stops. When small quantities, say ten to twenty pounds of milk are separated, a great deal of cream remains in the bowl, even though the whole of the skimmilk is run through the second time. For 14 tests with an average of 15 pounds of milk in which the entire amount of skimmilk was run through the separator the second time to wash it out, the milk remaining in the bowl contained on the average 3.78 per cent of fat. Just about one-tenth of the entire fat in the whole milk remained in the bowl, although the skimmilk of these 14 trials averaged only 0.11 per per cent fat. It was evident from these tests that the separator could not be successfully used for handling single milkings, or even the two milkings of a day. It had been found in previous work that on increasing the quantity of milk handled, the mechanical loss decreased, and this principle was acted on in the further work.

It was found after repeated trials to be possible to hold the milk of a single cow submerged in ice-water for several days and have it remain sweet, and that if heated to 90°–95° by setting the can containing it into hot water and stirring the milk thoroughly while it was warming, it was possible to run this milk through the separator and get as complete separation as though the milk were handled while still warm, fresh from the cows. It was also found that when these large quantities of milk were put through the separator, and a correspondingly large quantity of warm skimmilk run through at the end of the work the fat was cleared out quite thoroughly from the bowl so that the skimmilk remaining in the bowl tested only 0.40 per cent fat. The endeavor was made at first to hold the milk for a week and then run it through. This was not a success as in some cases the first milkings became so nearly sour that they did not handle to good advantage, and the cream during this long period became so compacted that it was difficult to stir it back and get it to come out of the cream slot. Four days and three days were finally settled on as the most convenient time to separate in a week's test. All tests are commenced with the evening's milking, separating it at the end of the first four days and again at the end of the next three days. This allows the milk of the first four days to be submerged in a four-can Cooley creamer, and the cream from these four days, with the milk of the other three days to be contained in the same tank.

In the test below reported, great care was taken to have no loss of fat mechanically. Each of the cans used to set the whole milk was washed out twice with skimmilk and the washings run through the separator. The cream from the first separation was put into the churn and then the can washed out repeatedly with skimmilk and the rinsings run through the separator. The can holding the last cream separated was rinsed out with a small amount of skimmilk and the rinsings added to the cream in the churn. The cream was churned at once, sweet, at a temperature of 50°. The churn used in this test was the Moseley & Stoddard barrel churn, No. 2. The churning required nearly fifty minutes, which was due largely to the fact that the churn used was small for the quantity of cream which filled it rather more than half full. With a larger sized churn the churning could probably have been done sooner, and possibly with a smaller loss in the buttermilk. Some may claim that more perfect churning could probably have been done had the cream been allowed to stand until it ripened. This is probably not so. Churning small quantities of cream and getting a buttermilk with less than 0.40 per cent fat is a difficult matter.

The following are the figures of a seven day's test of a single cow, and will serve to indicate the methods used. The evening's milk was weighed, sampled, and then the remainder poured into a Cooley can, the can weighed empty and then again after the milk had been poured in, the difference being the weight of milk set. The next morning's milk was treated in the same way, and added to the same can, the can being weighed before the milk was added and after. This second weighing was found necessary because in every instance the cans weighed more in the morning than at night; some water seemed to have forced its way in, though the valves seemed perfectly tight. The milk set and its analysis is as follows:

	Milk set lbs.	Fat %	Fat lbs.
February 9 p. m.	17.9	3.88	.594
" 10 a. m.	17.5	4.28	.749
" 10 p. m.	18.1	4.15	.751
" 11 a. m.	18.3	3.85	.704
" 11 p. m.	17.4	3.75	.652
" 12 a. m.	18.3	3.70	.687
" 12 p. m.	18 5	3.38	.625
" 13 a. m.	17.3	3.80	.657
" 13 p. m.	16.9	3.54	.598
" 14 a. m.	16.2	3.54	.573
" 14 p. m.	15.7	3.38	.530
" 15 a. m.	16.2	3.60	.583
" 15 p. m.	14.6	2.99	.436
" 16 a. m.	15.3	3.36	.530
Total for week.	238.7	3.66	8.674

During the first four days there were set 143.3 pounds milk which during the setting increased to 147.2. When run through the separator, this was divided into 20.8 pounds cream, 123.1 pounds skimmilk and 2 pounds bowl slop, unaccounted for, 1.3 pounds. The last three days the milk set was 95.4 pounds, when run through the separator it weighed 98.1 pounds, cream 14.8, skimmilk 81.6, bowl slop 2 pounds giving gain of 0.3 pounds. The cream when churned yielded 9.65 pounds butter and 26 5 pounds buttermilk. The analyses showed the skimmilk 0.14 per cent, fat, bowl slop 0.40, buttermilk 0.39, butter 85.96, so that the whole account stands as follow :

Butter fat in whole milk		8.674 lbs.
BUTTER FAT RECOVERED.		
Skimmilk	204.70 lbs.× 0.14=0.286	
Bowl slop	4.00 lbs.× 0.40=0.016	
Buttermilk	26.25 lbs.× 0.39=0.102	
Butter	9.65 lbs.×85.96=8.295	8.699 lbs.

There is almost a perfect agreement between the fat used and fat recovered, the difference amounting to 0.02 pounds. Fat in whole milk, 8.674 ; fat recovered in butter 8.295 ; there was therefore exactly 95 per cent of the fat in the whole milk recovered in the butter. When reduced to the 80 per cent, standard, this cow would be credited with 10.37 pounds of standard butter or 119 pounds of butter for each 100 pounds of fat in the original whole milk.

XII. ABNORMAL MILKS.

BY W. W. COOKE AND J. L. HILLS.

The registered Devon cow Nellie Bly, 3d, owned by the Station, dropped a calf on July 17, 1890, and died of milk fever on the 19th. She gave on the morning and afternoon of the 18th, colostrums containing :

	Spec. Grav.	Total Solids.	Fat.	Casein and Albumen.	Milk Sugar and Ash.
A. M.	1.050	19 34	2.20	11.84	5.30
P. M.	....	16.02	2.55	8.14	5.43

That given on the morning of the 19th, a few hours before her death, was less than a quart in quantity and *creamed with the cream at the bottom and skimmilk at the top.*

They were carefully separated and analyzed, the results being :

	Spec. Grav.	Total Solids.	Fat.	Casein and Albumen.	Milk Sugar and Ash.
Skimmilk,	1.0201	5.95	0.14	3.96	1.85
Cream,	1.0215	11.30	4.38	4.93	1.99

It will be noted that specific gravities bear out the remarkable nature of the separation. It was probably caused by an enormous excess of fibrin, due to the disease, entangling the fat globules and preventing their rising.

The Jersey Cow Beauty, owned by the Station, was milked up to the time of calving. The night before and a few hours after she calved her milk contained:—

	Total solids.	Total solids calculated.	Fat.	Casein and Albumen.	Milk Sugar and Ash.	Solids not fat.	Specific gravity.
Before	21.45	21.34	10.18	6.35	4.92	11.16	1.0365
After	19.14	18.82	7.48	6.48	5.18	11.66	1.0394

The cow instead of giving colostrum gave milk. Succeeding flows were analyzed and found slightly more colostral than the first. Under the microscope but few colostrum particles were found in the first milk and not many in any of the others.

Apparently the recent milkings had so strongly established the milking habit that the system could not readjust itself at once to the changed condition of affairs after birth.

A registered Jersey cow, Daisy Hanmer, owned by the Station, attracted attention on account of the richness of her milk, being the richest ever analyzed at the Station. The last milking before she went dry, though of course small in quantity, had the enormous amount of 28.43 per cent total solids.

The full analysis was:

Total Solids	28.43	per cent.
Fat	14.67	"
Solids not Fat	13.76	"
Casein and Albumen	9.98	"
Ash	1.44	"
Sugar, by difference	2.33	"

This milk is remarkable for the small amount of milk sugar, the high amount of albuminoids and ash and the excessively large amount of fat. This, with some other milkings of the same cow, is probably the only milk analysis on record in which the fat is more than the solids not fat.

The milk given by this cow is of such an unusual character that the records are given herewith of the last few weeks before she went dry. At the time the tests began it was taking from 11 to 12 pounds of milk to make a pound of butter. This amount decreased until less than seven pounds were required.

MILK RECORD OF THE COW "DAISY HANMER."

Date.	Milk Given.	Analysis of Milk.			Fat Given.
		Total Solids.	Fat.	Solids not Fat.	
	lbs.	%	%	%	oz.
1891.					
Dec. 6. P. M.	8–		8.40		10.75
7. A. M.	10–		7.93		12.69
22. P. M.	9– 8		7.58		11.52
23. A. M.	12–		7.52		14.44
23. P. M.	8– 8		7.67		10.43
24. A. M.	11–		6.92		12.18
24. P. M.	9–		7.58		10.92
25. A. M.	10– 8		7.14		11.96
25. P. M.	8–12		7.83		10.96
26. A. M.	10–12		6.71		11.54
26. P. M.	10– 8		7.80		13.10
27. A. M.	10– 4		6.52		10.69
27. P. M.	7– 8		7.57		9.08
28. A. M.	9– 4		6.76		9.73
28. P. M.	6–		7.88		7.56
29. A. M.	8–12		6.73		9.42
Jan. 1-4*	6–11	17.94	7.45	10.49	7.97
16-19*	6– 6		8.00		8.16
Feb. 1-4*	5– 3	19.81	8.75	11.06	7.26
16-20*	3– 7	21.59	9.75	11.84	5.36
23. P. M.	3–	21.50	10.14	11.36	4.87
24. A. M.	4–	19.37	9.20	10.17	5.88
24. P. M.	3–		9.10		4.37
25. A. M.	3– 8		9.00		5.04
25. P. M.	3–		8.45		4.06
26. A. M.	3–		8.68		4.17
26. P. M.	2–	21.18	10.15	11.03	3.25
27. A. M.	2– 4	23.05	11.25	11.80	4.05
27. P. M.	1–12	21.06	10.26	10.80	2.82
28. A. M.	2– 4	22.04	10.31	11.73	3.71
28. P. M.	2– 2	21.80	10.23	11.57	3.48
29. A. M.	2–11	21.27	9.90	11.37	4.26
29. P. M.	2– 2	21.62	10.48	11.14	3.56
March 1. A. M.	2–	22.02	10.90	11.12	3.49
1. P. M.	2– 2		9.66		3.28
2. A. M.	1–12	22.10	10.50	11.60	2.94
2. P. M.	1–11	21.69	10.55	11.14	2.85
3. A. M.	1–10	22.88	11.35	11.53	2.95
3. P. M.	1– 7	22.16	10.75	11.41	2.47
4. A. M.	2–	21.22	9.50	11.72	1.52
4. P. M.	1– 4	21.64	10.20	11.44	2.04
5. A. M.	1– 8	21.78	10.47	11.31	2.51
5. P. M.	1– 8		8.83		2.12
6. P. M.	2– 8		9.43		3.77
7. P. M.	1–11	22.21	10.28	11.93	2.78
9. A. M.	2– 9	22.18	11.33	10.85	4.64
11. P. M.	1– 8	25.55	12.98	12.57	3.11
14. P. M.	– 8	28.43	14.67	13.76	1.13

*Average.

XIII. THE USE OF A FORMULA FOR CALCULATING THE PER CENT OF TOTAL SOLIDS IN MILK.

BY W. W. COOKE AND J. L. HILLS.

It has long been known that there is a definate relation between composition and specific gravity in milk, and that this relation is constant enough to admit of either total solids, fat or specific gravity being found by calculation provided the other two are known. Several formulae have been proposed by Fleischmann,[*] Hehner and Richmond, [†] Babcock [‡] and others for this calculation and it is now possible for any one who can use a Babcock tester and a lactometer to calculate the percent of total solids with almost the accuracy of chemical analysis and determine adulteration, its amount and its nature.

Thanks to the rapid methods of fat estimation of the last few years, the errors of observation fall upon the solids not fat, the least valuable part of the milk, and the field for the use of the formulas is widened. These formulas differ slightly among themselves, some are more complicated than others, but within narrow limits they agree with each other in calculated results and with truth. Much time was spent comparing and applying these formulas to analyses from various sources, American and foreign, which reported all three factors, specific gravity, total solids and fat, as having been found by actual analysis. It was found that in the long run a simplification of the Hehner & Richmond formula for fat, transposed into a formula for solids, fitted the conditions of American milks more closely than any other. The formula is $T = 1.2\,F + \frac{L}{4}$, in which T = total solids, F = fat and L = lactometer reading at 60° F. In other words one-fourth the lactometer reading added to one and one-fifth times the fat gives the total solids.

We have applied the formula to some of our own work with the following results. In eighty-three comparisons on the milks of single cows, with seven only did analysis and calculation on total solids vary over 0.20 per cent, in five of which the cows were strippers giving rather abnormal milks. In seventeen cases on an exceedingly abnormal milk, that of a registered Jersey stripper, total solids varying from 20.35 to 23.05 per cent and fat from 9.45 to 11.35 per cent, analysis and calculation on total solids agree within 0.30 per cent in thirteen cases, within 0.40 in sixteen. Formula and analysis do not agree on colostrum until the fourth milk. Applied to herd milks a yet closer agreement is found.

The original Hehner & Richmond formula is for the calculation of fat percentage from the total solids and specific gravity determinations. It throws errors in either determination upon the fat and is tedious to use. The simplified formula presented herewith throws the errors upon the less valuable constituents of the milk and is easily used. Anyone having occasion to use this formula often, can shorten the already simple calculation by making two tables, one giving one and two-tenths times each fat percentage, the other one-fourth each lactometer reading. Using these the calculation of total solids becomes but a simple addition of two numbers. Or a simple cross-reference table, correct within 0.05 per cent, can be made giving total solids for each half-point on the lactometer and tenth of a per cent fat reading.

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[*] Journal für Landwirthschaft 1883 pp. 251-269.

[†] The Analyst. Feb. 1888, p. 26-36.

8th Anl. Rpt. Wis. Expt Sta. p. 292-307.

DETECTION OF ADULTERATION IN MILK BY THE USE OF MILK FORMULAS.

In nearly all of the cheese factories of the State and in a few of the creameries, milk is still paid for by weight without regard to its quality, that is, all the milk received during a given month is paid for at the same rate per hundred pounds whether it is rich or poor. This puts a premium on adulterating and in most communities there are some who are not proof against the temptation and will water the milk or skim it or both before bringing it to the factory. The rational way is to analyze the milk as delivered and pay for it according to its value, thus removing all temptation to unfair dealing, and it is a hopeful sign of the times that nearly all the creameries of the State have adopted this system.

Where the temptation to tamper with the milk still exists, it is well for the factoryman to be on his guard and have the apparatus for determining whether or not his patrons are delivering whole unadulterated milk.

The Vermont State milk law is explicit as to what is not legal milk. It declares it to be unlawful to add water to milk, to take off any of the cream or to bring to a factory milk which contains less than three and a quarter per cent of fat or twelve and a half per cent of total solids.

Every factoryman should be able to analyze the milk and determine whether it is up to the legal standard. The instruments he needs are a Babcock tester for measuring the fat and a lactometer (Quevenne pattern) for obtaining the specific gravity from which the total solids can be calculated. Both of these instruments can be obtained from any dealer in dairy implements.

When milk is brought that is suspected, the method of analysis is as follows: The per cent of fat is found with the Babcock tester. The milk is then warmed or cooled to *exactly* 60° F. and the reading of the lactometer taken. One-fourth the reading of the lactometer added to one and a fifth times the fat gives the total solids. Subtracting the fat from the total solids leaves the solids not fat.

Thus, if the milk analyzes 4.00 fat and tests 31 by the lactometer, *the total solids* would be 4.00+(⅕ of 4.00=0.80)+(¼ of 31=7.75)—12.55 and the *solids not* fat would be 12.55—4.00=8.55.

If, then, the factoryman knows the per cent of fat and the lactometer reading he has good grounds for knowing whether or not the milk is all right. The fat of milk is very variable, but the lactometer readings, and the solids not fat are quite constant in whole milk. It is necessary to know with great exactness the variations and limits of normal milk in order to know what milks to consider adulterated. Whole milk may vary in *fat* from 2.00 per cent to 8.00 and in extreme cases even more.

The law considers all milk illegal that contains less than 3.25 per cent fat. It makes no difference whether this low amount of fat comes from watering, from skimming or from poor cows, if the milk shows less than 3.25 per cent of fat the patron is liable to a fine of fifty dollars.

The *lactometer readings* of the whole milk of herds vary but little, seldom going above 33 and *never below 29.* If then a milk is found showing a reading of 28 or lower, *it is certainly watered.* This cannot be too strongly urged, because there has come lately a disposition to belittle the value of the lactometer as a detective.

The *solids not fat* in the whole milk of herds is usually from 8.75 to 9.25, seldom goes below 8.40 and *never below 8.10.* All milks with solids not fat below 8.10 must be considered as watered.

The skimming of milk can never be detected with as much certainty as the watering, but several cases may arise which will make it probable that the milk has been skimmed. Skimming makes the solids not fat higher and gives a higher reading to the lactometer. Thus a milk showing 3.50 per cent fat and 9.50 solids not fat would indicate that the milk had probably been skimmed of at least fifteen per cent of its fat.

Only one rule can be given for the certain detection of skimming and that is to compare the analysis of the milk brought to the factory, with the analysis of a sample taken at the barn. If the factory sample has been skimmed it will show less fat, more solids not fat and a higher lactometer reading.

It should always be remembered that the necessity for all these tests is but the outgrowth of a wrong system of payment and that the proper and only just way is to remove all the temptation by paying for milk according to its real value.

SEPARATOR SKIMMILK.

There is a belief quite prevalent among certain classes that the separator has some mysterious influence on the skimmilk to make it of different quality from the skimmilk of ordinary setting. This difference is considered to extend not merely to the fat, but to influence the other ingredients. This view has also received a semi-official sanction in a late publication of an American experiment station. To ascertain the truth of the matter three samples of milk were tested before and after running through the separator. Determinations were made of total solids and fat, and then in each case the calculation was made as to what the milk would contain if the fat was taken out, or to use the technical term, a calculation was made of the solids in the milk serum. An example will show what is meant. If 100 pounds of milk contains 4 pounds of fat and 8 pounds of solids not fat, and the 4 pounds of fat are taken away there remains 96 pounds of milk containing 8 pounds of solids which would therefore not be 8 per cent but 8 ÷ 0.96 — 8. 33 per cent. Hence the milk serum of this sample contains 8.33 per cent solids not fat. In the table below, the samples marked "b" are the skimmilks from the "a" samples.

Sample.	Total Solids. %	Fat. %	Solids not Fat.	1.00 minus per cent Fat.	Calculated Solids not Fat in Milk Serum.	
					Whole Milk.	Skimmilk.
1 a..........	12.04	3.28	8.76	.9672	9.06	
1 b..........	9.40	0.28	9.12	.9972		9.16
2 a..........	14.31	5.07	9.24	.9493	9.73	
2 b..........	9.78	0.10	9.68	.9990		9.69
3 a..........	15.75	6.19	9.56	.9381	10.19	
3 b..........	10.28	0.17	10.11	.9983		10.13
Average	---- ----	---- ----	---- ----	---- ----	9.66	9.66

It is evident from these figures that the milk serum is not influenced by the separator and that the only difference between whole milk and the skimmilk derived from it, is in the amount of fat they contain.

RELATIVE VALUE OF SKIMMILKS.

These same figures may be used to show the fallacy of the popular notion that the skimmilk from the so-called "cheese-cow" is more valuable than that from the "butter-cow." The first sample of milk containing 12 per cent solids and 3¼ per cent fat is a fair sample of a cheese-cow's milk, while the last with 15¾ per cent solids and 6 per cent fat is a first-class milk for butter, and yet after taking out this large amount of butter, more than a pound for each 16 pounds of milk, the skimmilk that remains, blue though it is to the eye, contains 10 pounds of solids to the hundred, while the white and dense looking skimmilk from the cheese-cow contains but 9 pounds. The difference in market value is too small to be noticed, about a cent for a hundred pounds, but whatever difference there is, is in favor of the skimmilk from the butter-cow.

XIV. COMPOSITION ON MILK AND ITS PRODUCTS.

The following tables show the average composition and the fertilizing ingredients of milk and its products, together with the average distribution of both the milk and the fertilizing ingredients in butter and cheese making, being compiled and calculated from the analyses of American Experiment Stations.

It should be said that the fat percentages in skim and butter milks are lower than will usually be found in shallow setting work and that of butter higher than will usually be found in creamery butter.

In a dairy of twenty cows giving 4000 pounds milk apiece yearly, the total fertilizing value of the milk for a year will approximate $86.80 all of which is *lost to the farm* if the whole milk be sold, two-thirds ($56.80) if cheese is sold and whey retained, one sixth ($13.20) if butter is sold and the butter milk left at the factory, one-onehundredth ($0.86) only if butter is sold and both skimmilk and buttermilk fed upon the farm:

	MILK INGREDIENTS.							FERTILIZING INGREDIENTS.			
	% Total solids.	% Fats.	% Casein.	% Albumen.	% Milk sugar.	% Ash.	Part of total fat found in product.	% Nitrogen.	% Phosphoric Acid.	% Potash.	$ Value per ton.
Whole milk, average	13.00	4.00	2.60	0.70	4.95	0.75		0.53	0.19	0.175	2.17
Whole milk, maximum	17.00	8.00	3.60	0.90	5.50	0.90					
Whole milk, minimum	10.00	2.00	1.60	0.40	4.00	0.60					
Skimmilk	9.75	0.30	2.75	0.75	5.15	0.80		0.56	0.20	0.185	2.31
Cream	25.95	18.80	2.00	0.50	4.15	0.50		0.40	0.15	0.130	0.66
Buttermilk	9.50	0.50	2.40	0.60	5.30	0.70		0.48	0.17	0.158	1.98
Whey	7.03	0.50	0.15	0.78	5.00	0.60		0.15	0.14	0.181	0.84
Butter	80.90	85.00	0.60	0.15	0.00	0.15		0.12	0.04	0.036	0.49
Cheese	66.75	35.50	24.65	0.00	4.50	2.10		3.93	0.60	0.120	14.19
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.		lbs.	lbs.	lbs.	$
1000 pounds milk contains,	130	40	26	7	49.5	7.5		5.3	1.9	1.75	2.17
which would make 800 pounds skimmilk, containing	78	2.4	22	6	41.2	6.4	6	4.5	1.6	1.50	1.84
and 200 pounds cream, containing,	52	37.6	4	1	8.3	1.1	94	0.8	0.3	0.25	0.33
which would make 187 pounds buttermilk, containing	14.91	0.8	3.77	0.94	8.3	1.1	2	0.75	0.27	0.24	0.31
and 43.3 pounds butter, containing	37.09	36.8	0.23	0.06			92	0.05	0.03	0.01	0.02
or 1000 lbs. milk would make 900 pounds whey, containing	63.25	4.5	1.35	7	45.	5.4	11.25	1.35	1.23	1.63	0.74
and 100 pounds cheese, containing	66.75	35.5	24.65		4.5	2.1	88.75	3.95	0.65	0.12	1.43

PIG FEEDING.

By W. W. COOKE.

During the past year the Station has continued its work on pig feeding endeavoring to find the answers to certain questions which just at the present time are being frequently asked.

QUESTIONS ASKED.

1. Which is the better for young pigs, sweet skimmilk or sour skimmilk?
2. How much corn meal can profitably be fed to pigs?

ANSWERS RECEIVED.

1. **In every case sour skimmilk produced better results than sweet skimmilk.**
2. **Heavy feeding of corn meal produced a larger growth than moderate feeding, but at a larger expense for food for each pound of growth.**

The results obtained in three years of pig feeding have been consolidated and give the following results:

On the average during these three years the pigs have required 1.43 lbs. of dry matter in the food to make a pound of growth up to the time they weighed 53 pounds, and his amount increases steadily as the pigs increase in live weight, until when they weigh 201 pounds it has required 3.84 pounds of dry matter in the food to produce a pound of growth.

Nearly all the pigs cease to yield a profit after they have reached a live weight of about 180 pounds.

The value of skimmilk has varied in different experiments from 24 cents to 27 cents per hundred pounds, averaging 25 cents.

With the foods used, skimmilk, corn meal, bran, middlings, and gluten meal, the fertilizing value has been on the average 61 1-2 per cent of the cost of the food.

HISTORY.

The pigs used in the following experiments were small Yorkshires bought from L. S. Drew, Burlington. They were about six weeks old when the experiment began, May 18, and the feeding continued until October 27. In the experiment to test the difference in the feeding value between sweet skimmilk and sour skimmilk, the skimmilk fed was nearly all from deep cold setting. That which was to be fed sweet was warmed enough to take off the chill and fed at once. That which was to be fed sour was left in an open tub until it became thoroughly lobbered and rank, very often fully wheyed off. It was probably as fully sour as any skimmilk from separator creameries ever gets before it is fed out, when during the hottest days no attempt is made to keep it sweet. The pigs were fed with what skimmilk they would eat, two ounces of corn meal being added to each quart of skimmilk until the pigs were large enough to take six quarts of skimmilk and twelve ounces of corn meal daily. After that whatever additional food they desired was made up of a mixture of equal parts by weight of wheat bran and gluten meal. The twelve ounces of corn meal and six quarts of skimmilk daily was continued through the rest of the test. In the test of heavy corn meal feeding, the corn meal was mixed with sweet milk in the proportion of one pound of meal to each quart of skimmilk, and the pigs were given all they would eat up clean of this mixture. All the pigs were given two weeks of feeding on clear skimmilk before they were given any grain feed. The pigs were fed all they wanted or rather all they could be induced to eat.

DAILY RATIONS OF PIGS.

SWEET AND SOUR SKIMMILKS.

Period.	Date.	Skimmilk. qts.	Corn Meal. oz.	Bran and Gluten Meal. oz.	Nutritive Ratio.
I	May 18-23	1.3			2.05
	" 24-30	3			
	" 31-June 6	3.5			
	June 7-12	3	2		
	" 13-19	4.5	6		
	" 19-28	6	6		
II	" 29-July 3	6	12		2.60
	July 4-10	6	12	6	
	" 10-17	6	12	9	
	" 18-24	6	12	13.7	
	" 24-31	6	12	17.3	
	Aug. 1- 7	6	12	25.	
III	" 8- 9	6	12	29.8	2.55
	" 10-14	6	12	29.8	
	" 15-28	6	12	33	
	" 29-Sept. 11	6	12	36	
	Sept. 12-Oct. 26	6	12	39	

CORN MEAL.

Period.	Date.	Skim-milk. qts.	Corn Meal. oz.	Nutritive Ratio.
I	May 18-23	1.3		3.30
	" 23-30	3.		
	" 31-June 6	4.5		
	June 7-12	3.	5	
	" 13-19	1.4	23	
	" 20-26	1.5	24	
	" 27-28	2.25	36	
II	" 29-July 3	2.25	36	5.45
	July 4-10	3.	48	
	" 11-17	4.	53.8	
	" 18-24	3.75	55.7	
	" 25-31	4.18	59.6	
	Aug. 1- 7	4.7	66.4	
	" 8- 9	5.7	82	
III	" 10-14	5.7	82	5.20
	" 15-Oct. 26	6.	87	

GAIN IN LIVE WEIGHT BY PERIODS.

Sweet Skimmilk.				Sour Skimmilk.				Corn Meal.			
Period	Live Weight at beginning of Period.	Live Weight at end of Period.	Gain in Live Weight during Period.	Period.	Live Weight at beginning of Period.	Live Weight at end of Period.	Gain in Live Weight during Period.	Period.	Live Weight at beginning of Period.	Live Weight at end of Period.	Gain in Live Weight during Period.
I	16	42	26	I	17	48	31	I	21	54	33
II	42	89	47	II	48	101	53	II	54	121	67
III	89	173	84	III	101	191	90	III	121	258	137

GAIN IN LIVE WEIGHT DURING TEST.

Pigs' Food.	Number of Days.	Total Gain. lbs.	Average Daily Gain.
Sweet Milk	162	154	0.95
"	162	157	0.97
"	162	162	1.00
Sour Milk	162	182	1.12
"	162	176	1.09
"	162	166	1.03
Corn Meal	162	237	1.46
Total	1134	1234	1.09
Average Sweet Milk		158	0.97
" Sour Milk		175	1.08
" Corn Meal		237	1.46

TOTAL AMOUNT OF FOOD EATEN.

Pig No.	Food.	Skimmilk. qts.	Corn Meal. lbs.	Bran and Gluten Meal, lbs.
I	Sweetmilk.	924.4	97.56	214.10
IV	"	946.4	97.60	214.10
VII	"	946.4	97.60	214.10
III	Sourmilk.	917.4	95.06	207.68
VI	"	936.4	97.60	214.10
VIII	"	934.9	97.60	214.10
V	Corn meal.	792.4	595.05	——
Total.		6398.3	1178.07	1278.18

FOOD REQUIRED TO PRODUCE A POUND OF GROWTH.

Pig No.	Food.	Total dry matter fed. lbs.	Total gain in live weight. lbs.	Dry matter eaten for one pound gain in live weight. lbs.
I	Sweetmilk.	468.17	154	3.04
IV	"	472.79	157	3.01
VII	"	472.79	162	2.92
III	Sourmilk.	458.84	182	2.52
VI	"	470.69	176	2.67
VIII	"	471.38	166	2.83
V	Corn meal.	668.43	237	2.82
Total.		3482.09	1234	
Average.		497.44	176.3	2.82
Average of Sweet Milk			158	2.99
" " Sour Milk			175	2.67
" " Corn Meal			237	2.82

If corn meal be considered worth $24.00 per ton, gluten meal the same, wheat bran $20.00 per ton and skimmilk 15 cents per hundred pounds, the food required to produce one pound of gain in the pigs on sweet skimmilk cost 4.15 cents, in the sour milk pigs 3.72 cents and in the pig on corn meal 4.09 cents.

SWEET SKIMMILK VS. SOUR SKIMMILK.

A study of the preceding tables will show that the sour skimmilk produced the better results in every case. To one who watched the pigs from day to day it was not necessary that the pigs be weighed in order to show that they **were doing the better on the sour skimmilk.** It was evident within three weeks after the pigs were put on the separate diets that those having the sour skimmilk were eating their food with a better relish, were looking sleeker and growing faster, although both lots ate their food-up clean, so that they actually consumed the same amount of nutriment. It has been taught widely during the last year that the patrons of separator creameries were losing largely by allowing the skimmilk to sour before they got it to their pigs. This statement was based on the fact that in souring the milk sugar is changed to acid and therefore a large amount of the feeding value was supposed to be lost. A rather extensive canvass among farmers recently showed quite a decided preponderance in favor of pigs doing better on sour milk than on sweet. How then can we explain and harmonize the two statements? The probable reason is found in the fact that when milk sours the milk sugar is broken up into lactic acid, but this change takes place without any loss of solid matter. One particle of milk sugar merely absorbs some water and splits up into two particles of lactic acid. Recent experiments in Germany seem to show conclusively that lactic acid in common with several other vegetable acids is digested and has a real feeding value, therefore the lactic acid being in the same quantity as the milk sugar, it is fair to presume that its feeding value would not be reduced. If milk is allowed to stand for several days this lactic acid breaks up into butyric acid and carbonic acid gas, the latter passing off and becoming certainly a dead loss. It could not be said from our experiments that skimmilk could be kept indefinitely, and still not lose in feeding value, but it seems probable that there is no loss in feeding value in the first change of souring and lobbering. As to why the sour skimmilk should have done better than the sweet skimmilk, we cannot tell, unless the answer is found in the greater relish with which it is eaten or unless it is a fact that the acid during the hot weather, keeps the digestion of the pigs in a little better condition.

HEAVY FEEDING OF CORN MEAL.

In our previous experiments on pig feeding we have followed the rule of nature, which is to feed young pigs with food having a large preponderance of the muscle or flesh forming elements, and as the pig grows older to decrease this proportion and gradually increase the amount of heat or fat producing material. In other words to feed at first a narrow nutritive ration about 1:2, and to gradually widen this until during the finishing off process the pig receives a ration of about 1:5. During the present course of feeding a different mode of proceedure was adopted. The pigs that were on the skimmilk test received a ration that from first to last contained a large amount of albuminoids. The ratio varied within narrow limits of from 1:2 to 1:2¼. In addition to this we selected two pigs and put them on quite an unnatural diet for young pigs. We fed them heavily with corn meal from the time they were seven weeks old and the proportions of the rations were not varied during the whole period. In other words we took the ration which is usually used for the finishing off period, and fed it in unchanged proportions throughout the whole test. As would be naturally expected the test did not prove a success. The ration proved too much for one of the pigs and it died within three weeks after the test began. The other pig continued through the test in good health and grew faster than the pigs in the skimmilk test. But the extra growth was obtained at the cost of more than a proportionate amount of feed, so that in the animal ready for market a pound of pork had cost more than in the other pigs. During the earlier part of the test when it was given too wide a ration for its age it did not do so well as the skimmilk pigs, but during the last few weeks when it had grown up to its ration it did better than they.

FINANCIAL SUMMARY.

The pigs as a whole, while we fed them, produced a profit over the cost of the food they ate. They made a total gain in live weight of 1234 pounds which sold for $61.65, while the food they ate cost $44.87, a profit of $16.78. This is based on $24 a ton for corn meal and gluten meal and $20 a ton for bran, which were the prices ruling at the time the experiment was made.

VALUE OF SKIMMILK.

In the figures just given above the skimmilk has been given an assumed value of 15 cents per hundred pounds. Another way of figuring would be to subtract from the price received for the pigs the total amount paid out for grain and consider the balance as what was received for the skimmilk. The increase in live weight in the pigs brought $61.65 and they ate $24.23 worth of grain. This would leave $37.42 as the amount received for the skimmilk they ate, which was 13,756 pounds. This would be equivalent to about 27 cents per hundred pounds.

FERTILIZING VALUE OF FEED.

This is much larger than is usually supposed and in the above experiments gave results as follows:

COMPOSITION OF FEED IN POUNDS PER TON.

	Nitrogen.	Phosphoric Acid.	Potash.	Valuation.
Skimmilk	11.0	4.1	4.2	$2.29
Corn Meal	29.0	12.8	8.0	6.04
Wheat Bran	49.7	60.7	31.3	13.42
Gluten Meal	123.	7.1	4.0	21.51

The total fertilizing value of the food eaten is **$30.49** from food costing $44.87, the fertilizing value thus representing **68 per cent** of the market value of the food.

GENERAL SUMMARY OF PIG FEEDING EXPERIMENTS.

For three years now we have been experimenting in feeding pigs, and it may be well enough to consolidate the different figures. Most of the feeding has been modifications of one general plan, the pigs being started on skimmilk either sweet or sour and fed all they would eat of this until they took six quarts a day, after which the amount of skimmilk remained constant at this quantity, and the rest of the ration was made up of constantly increasing quantities of grain. The trials as a whole have shown that skimmilk can be profitably used for pig feeding or rather that pigs can be grown with profit where there is skimmilk to serve as part of the ration. In all of our work the attempt has been not to see how large a number of pounds of pork could be grown in a given time, but to see with how little food it is possible to grow a pound of first class pork. In this particular line we have been eminently successful. The first year requiring 2.79 pounds of dry matter in food to one pound of gain in live weight. The second year 2.92, and the third 2.82 an average for the whole, of **2.84.** The best results were obtained on one pig in 1889, which consumed but 2.40 pounds of dry matter for each pound of gain in live weight. The poorest results were obtained in 1890 when two pigs each required 3.20 pounds of dry matter to each pound of gain in live weight.

A study of the rations ordinarily fed on the farm, and the results obtained leads to the conclusion that in the best of farm practice a pound of gain in live weight is seldom obtained with less than 3¼ to 3½ pounds dry matter in the food. With corn meal, gluten meal, and middlings at $26 a ton and bran at $24, all of these prices being exceptionally high, and with the pork selling at 5 cents a pound live weight, and with skimmilk at 15 cents per hundred pounds, the food to produce a pound of live weight, has cost on the average **4.19** cents, and has returned a gain of 19 per cent over cost of feed. If from the selling price we subtract the amount paid out for grain and consider the balance as what we have received for the skimmilk, we find the amounts varying in the different experiments from 24 to 27 cents, an average of **25** cents per hundred pounds. In addition to this we find that there has been returned in the fertilizing value of the food just about two-thirds of the cost of the food, so that if we consider the fertilizing value as offsetting the labor, there has been returned a large value for this labor.

REPORT OF THE BOTANIST.

L. R. JONES.

Fungous diseases of plants and their remedies have again been made the principal subjects of investigation in this department.

It is now proved beyond question that some of our worst plant diseases can be economically checked, if not prevented, by the intelligent use of fungicides, and we hope that the value of the copper compounds as remedies for potato blight and similar diseases, will soon be as well understood as is the value of Paris green in destroying the insect enemies of our crops. While the general practicability of spraying to check potato blight and other fungous diseases of plants, is then no longer a subject for experimental research there are many practical questions of immediate importance concerning the best times and methods of applying these remedies as well as the question as to what is the best kind and strength of remedies to use in each case.

Since this report could not be distributed early in the season, the most practical results of the work have been prepared for publication in bulletin form*. It being undesirable to duplicate such matter in detail, only brief mention is here made of the subjects treated in this bulletin, and the bulletin itself may be considered in a measure as a part of this report.

Following is a list of the subjects discussed in this report:

I. Spraying with Bordeaux Mixture for the Potato Blight and Rot.
II. A Comparative Test of Several Fungicides for Potato Blight.
III. A New Potato Disease.
IV. The Prevention of Apple and Pear Scab by Spraying.
V. Apple-rust and Cedar-apples.
VI. A Spot Disease of Baldwin Apples.
VII. The Brown-rot of the Plum.
VIII. Oat Smut.
    (*a*) The Prevention of Oat Smut.
    (*b*) The Amount of Loss from Smut in Oats.
    (*c*) Will it pay to Disenfect Seed Oats.
IX. Effects of Various Fungicidal Treatments upon the Vitality of Seed Corn.
X. Lettuce Mildew and Lettuce Rot.
XI. Vermont Weeds.

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*Bulletin 28.

I. SPRAYING WITH BORDEAUX MIXTURE FOR THE POTATO BLIGHT AND ROT.

The nature and value of this remedy has been so fully discussed in our former publications that only brief mention of the results of the work of the past year will be made here.

The experiments at Burlington were cut short by the ravages of the new disease mentioned later in this report. Work was also carried on at the farm of J. E. White in Shelburne, O. E. Stone, Charlotte and Moses H. Kelsey, Salisbury. The results of this work are discussed so fully in Bulletin 28, that only the following tabulated statement is here given.

		Yield where Sprayed.	Yield where not Sprayed.	Gain in bu.	Per cent gain.
J. E. White's..	Sprayed Aug.20-Sep.8.	313 bu. per A.	248	65	26
O. E. Stone's..	" July 3, 23, Aug. 18.	206½ "	168	38½	23
M. H. Kelsey's	" July 20.	*	*		

In addition to the above gratifying results, letters were received from several potato growers who used the Mixture with good success. The most noteworthy facts aside from the above, brought out in these trials, were:

First: When a liberal application was made after the blight appeared but before it spread very badly, it was fairly well held in check.

Second: Where the treatment was successfully begun and continued up to Aug. 20, and then discontinued the disease reappeared and did considerable harm during September.

Third: The gain from increased yield due to prolonged life of the vines may exceed the gain from prevention of rot, as stated in Bul. 28: "Providing we can by spraying keep the tops alive three or four weeks longer in the fall, we may increase the yield over 25 per cent, to say nothing about the prevention of rot or improvement of the quality of the tubers due to thorough ripening."

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*One piece not sprayed, yielded 180 bu. of which 80 bu. rotted. Another piece that was sprayed, yielded 300 bu. of which less than one bushel rotted. Mr. Kelsey attributed the difference in the amount of rot to the use of the Mixture. The difference in yield was largely due to other causes.

II. A COMPARATIVE TEST OF FUNGICIDES FOR POTATO BLIGHT.

The value of Bordeaux mixture in checking potato-blight is settled beyond question. This fungicide however as ordinarily used is open to two serious objections. First, it is the most expensive of the standard fungicides; and second, the copper salt being insoluble forms a "sediment" which necessitates the constant stirring of the mixture during use and causes considerable trouble by clogging the nozzles of the spraying pump. These objections have suggested to all using the mixture, the desirability of some substitute or modification.

It seems hardly probable that any soluble fungicide can resist the washing of dew and rain so long as the insoluble Bordeaux mixture. The more hopeful outlook for improvement is therefore along the line of a more dilute form of the Bordeaux mixture. We made a comparative test of four fungicides upon potatoes this year. They were stronger Bordeaux mixture (6 lbs. copper sulphate, 4 lbs. lime, 22 gals. water); weaker Bordeaux mixture (6 lbs. copper sulphate, 4 lbs. lime, 33 gals. water), ammoniacal copper carbonate (5 oz. copper carbonate, 3 pints ammonia, 45 gals. water,) and glue mixture * (12 oz. sodium carbonate, 10 oz. copper sulphate, 8 oz. liquid glue, 45 gals. water.) The fungicides were applied to plots in five different potato fields. In two of these fields the "new disease" killed the vines before any of the true blight (*Phytophthora infestans*) appeared. In two others the injury to the vines sprayed with the ammoniacal copper carbonate, and also those sprayed with the glue mixture was quite marked within a few days after the first application—so much so, indeed, that the owners of the fields who had undertaken to make the test asked permission to discontinue the use of these fungicides. Another field of potatoes sprayed very liberally with these same fungicides showed not the slightest signs of injury from any of them even after three applications were made. In order to test the matter more fully the fungicides were applied on this latter field at the rate of about 25 gallons per acre, when the second application was made July 28, yet no signs of injury were seen. Possibly the variety of potato had something to do with it. The varieties showing injury were Garfields and Early Rose. The variety showing no injury was White Star.

Only one of these experiments was therefore carried through to the end of the season. That was upon a piece of late potatoes, White Stars, at Mr. J. E. White's of Shelburne. No applications were made until the disease appeared August 26, when blighting leaves were found on nearly every hill. Plots were then sprayed with each of the four fungicides under trial. Sept. 5, there was a marked difference in the various treated

*Recommended by B. T. Galloway.

and untreated plots, showing no benefit from the use of the ammoniacal copper carbonate, a very slight benefit from use of the glue mixture, more marked benefit where the Bordeaux mixture one-half strength was used, and very great benefit where the full strength Bordeaux mixture was used. September 8th when the second application of the fungicides was made the plots sprayed with the glue mixture and ammonical copper carbonate, were so badly diseased that the treatment was discontinued, nearly every leaf on the latter and more than half on the former being dead, and the remainder all dying. The applications of the two strengths of Bordeaux mixture were repeated. The potatoes were dug September 23, the workmen, not understanding directions made measurements of only the ones treated with Bordeaux mixture full strength and the adjoining untreated plots. The yields as reported in Bulletin 28 were at the rate of 313 bu. marketable tubers per acre where sprayed, and 248 where not sprayed, a gain of 65 bu. per acre or 26 per cent. These result would indicate therefore that both the glue mixture and the ammoniacal copper carbonate are liable to injure the potato leaves and were not at all equal to the Bordeaux mixture in efficiency; that the weaker Bordeaux mixture was not so good as the full strength mixture at least where the disease is well started. Had the experiments upon some of the plots where the applications were begun earlier been carried through to the close of the season the weaker fungicides would probably have given better results than they did in this case.

III. A NEW POTATO DISEASE.

A potato disease closely resembling the blight in its effects but entirely different in its real nature has been noted in our fields the past two years. This year the disease appeared very generally in the potato fields of the State. The appearance and probable bacterial nature of the disease are discussed in Bulletin 28.

The possibility of checking the spread of this disease by proper use of Bordeaux mixture is one of much practical interest. Dr. Halsted of the New Jersey Experiment Station, states that Bordeaux mixture has proved effective against the bacterial disease of the potato* and recommends its use. In our experience last summer the benefit from the use of Bordeaux mixture with this disease was very slight if there was any at all. The new disease spread over plots sprayed with Bordeaux mixture, with ammoniacal copper carbonate, and with glue mixture and did this in two different fields and at different times in the season. The first field was sprayed June 29th and 30th. The new disease was then just beginning to show and continued to spread over sprayed as well as unsprayed plots and fields all through July. By the middle of August all vines were dead. Another field of later potatoes was sprayed much more thoroughly. Liberal applications of each of the three fungicides were made to plots on July 9, July 28 and August 10. The disease had made considerable headway by the last date and plots sprayed with Bordeaux mixture were somewhat darker green and thriftier than the untreated plots on either side.* Ten days later the disease had killed the leaves upon nearly half the plants of the field.

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* Miss. Bul. 19, p. 12.

Very careful examination was made to determine the relative amount of the disease upon the various plots. The results showed very little if any difference in favor of the sprayed plots. By September 1, most of the leaves upon all plots were dead. October 3 the potatoes were dug. The yields were as follows :

Plot 1, untreated, 159 bushels per acre.
Plot 2, Bordeaux mixture full strength, 160 bushels per acre.
Plot 3, Bordeaux mixture ⅔ strength, 242 bushels per acre.
Plot 4, untreated, 181 bushels per acre.

These variations in yield agree closely with varying amounts of disease on these plots as shown by the notes taken August 20, hence it seems fair to infer that the difference in yield was due to the difference in disease, and this difference seems to bear no direct relation to the treatment. †

IV. THE PREVENTION OF APPLE AND PEAR SCAB BY SPRAYING.

The work along this line also is fully discussed in Bulletin 28, so that only a brief statement of the results is here given.

Ammoniacal copper carbonate, Bordeaux mixture and Solution No. 5 of the U. S. Dept. of Agriculture were used in the work upon the apple trees (Greenings), and ammoniacal copper carbonate upon the pear (a young Flemish Beauty tree). The pear was sprayed seven times, beginning May 19, just as the blossoms were opening, and repeated at intervals of about two weeks until August 8th.

The work upon the apple trees was also begun just before their blossoms opened. In most cases only four applications were made, the last being July 17th. Seven applications of the ammoniacal copper carbonate were made upon two of the apple trees, as upon the pear, but with only slightly increased benefits. The Solution No. 5 was used upon two trees, one Greening and one Fameuse, but injured the leaves so badly that its use was discontinued.

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*Since writing the above, Bul. 15 of the Delaware Station has been received. Prof. Chester in speaking of what appears to be this same disease says : "It has been claimed that the trouble can be held in check with the Bordeaux mixture, applied as directed in the former disease [potato blight]. This, however, was not the case in an experiment conducted by the writer in which several potato plots were sprayed thoroughly throughout the season with Bordeaux mixture, but in spite of heavy applications the plants went down completely before the tubers were the size of walnuts."

†This difference was hardly more than we have often noticed in favor of the sprayed vines when there has been no indication of any diseased condition, we have thought that it might be due to fertilizing action of the sulphate of lime (gypsum) contained in the Bordeaux mixture. Much the same stimulating result is often seen when gypsum mixed with Paris green is dusted upon the vines.

The results of the spraying briefly summarized are :

	Smooth Fruit.	Scabbed Fruit.
Flemish Beauty Pear—Sprayed tree	69%	31%
" " " Check tree not sprayed	28%	72%
Greening Apples :		
Ammoniacal Copper Carbonate, average of 5 trees	63%	37%
Bordeaux Mixture, average of 6 trees	74%	26%
Check trees, not sprayed, average of 9 trees	12%	88%

V. APPLE RUST AND CEDAR APPLES.

In our last annual report* mention was made of an attempt to control the rust upon apple leaves by spraying with ammoniacal copper carbonate. This rust is another stage of the fungus which causes the common "cedar apples" of red cedars. It is probable that the easiest way to get rid of the trouble is, therefore, to destroy the cedars themselves. It seemed desirable, as a matter of scientific interest, to try another year the efficacy of spraying before destroying the cedars.

Accordingly the same apple tree sprayed last season was again selected for the experiment. It was sprayed May 14. The cedar apples had begun to burst their coats at this time, but no gelatinous tongues were protruded. May 23 and June 15 a second and a third application were made. As a result of these applications the rust did not injure the foliage on this tree nearly so badly as on unsprayed trees, but, nevertheless, nearly every leaf had more or less of the rust upon it. The branches of a cedar tree on one side intermingled with those of the apple, and as this was loaded with "cedar apples" the possibilities of infection were very great. Still the results as tested last year would seem to show that spraying with ammoniacal copper carbonate does not offer a satisfactory protection against the rust so long as the red cedars are tolerated. It is now planned to remove the infested red cedars in or near the orchard and watch the effect another year.

VI. A SPOT-DISEASE OF THE BALDWIN APPLE.

While examining orchards in the fall it was noticed that many of the Baldwin apples showed sunken brown spots of the size of a pea or larger.

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*4th Rep. Vt. Exp. Sta., 1890, p. 139.

The flesh underneath the spot showed brown discoloration for an eighth of an inch or more in depth, and this discolored portion was quite bitter to the taste. Specimens of the diseased apples placed in a moist chamber soon developed small grayish pustules at or near the center of the spot, the pustule being from a sixteenth to an eighth of an inch in diameter. Microscopic examination of these pustules showed their fungous nature, and their general occurrence upon the center of the brown spots indicated a direct causal connection of the fungus with the spot.

Mr. J. B. Ellis of Newfield, N. J., identified the fungus as being probably *Dothidea pomigena*, Schu. Owing to lack of material a satisfactory study of the structure of the fungus was not completed. Inquiry among orchardists indicates that the disease is quite common upon Baldwin apples throughout the State. Its occurrence upon other varieties was not noted. Further study of the disease will be made another year.

VII. THE BROWN ROT OF PLUMS.

There was an unusually heavy crop of plums in most of the orchards of the State last year, and during the latter part of the summer the losses from the brown rot were very great. This rotting is often confused by the orchardist with the attack of the plum curculio. The rot often begins at the point where the insect punctures the fruit, but this is not necessarily the case. The disease may attack sound fruit as we satisfied ourselves by placing sound and decaying plums together under a bell glass. In a few days the disease appeared on the sound plums the germination spores having gained entrance through the unbroken skin.

The disease is caused by the attack of the fungus *Monilia fructigena.* The fungus spreads rapidly by spores which are extremely hardy. A "mummied" plum covered with these spores was brought into the laboratory in January. It was frozen solid of course and moreover completely covered with a coat of ice from a sleet that had fallen a few days before. Placed in favorable conditions in the warm room it soon thawed and a a few days later germinating spores were found. The disease is therefore capable of propagating itself from year to year in the decayed plums which remain through the winter, clinging to the trees or scattered on the ground.

The most important thing in the treatment of the disease during the summer, is therefore the prompt removal and destruction by fire or deep burial of all rotting fruit as soon as it appears. All "mummied" plums should be picked from the trees in the fall or winter, and if any have fallen to the ground they should be picked up and the ground ploughed to bury any that may be overlooked.

If the trees were badly affected the preceding year, spray the limbs and trunks before the buds swell in the spring, with a solution of copper sulphate (blue vitrol) in water, 1 pound blue vitrol to 16 gallons of water. Beneficial results have been reported where the trees were sprayed with ammoniacal copper carbonate a few times during the summer, and where the disease is bad, this treatment is recommended in addition to the above.

VIII. OAT SMUT.

(A) THE PREVENTION OF OAT SMUT.

The value of soaking seed oats for a few minutes in hot water in order to disinfect from smut is discussed in Bulletin 28. Methods varying in the temperature of the water used and in the length of time of immersion are recommended by different experimenters. A comparative test of several of these was made the past summer. The two methods most generally recommended are: (1) Soaking 15 minutes in water held at a temperature of 132°-135° F., then cooling with cold water. (2) Soaking 5 minutes in water at 136°-138° and spreading out at once to dry.

Portions of the seed designed for sowing in the regular oat field of the Experiment Farm were treated in each of the above ways. The latter method proved to be the more convenient, but the former was more beneficial to the grain as shown by improved germination and healthier color of young plants. The conditions of soil were such that it was not possible to get reliable data as to the effect of the treatment upon the yield of grain. Both methods were entirely effectual in destroying the smut. The portion of the field sown with untreated seed had over 4 per cent of smutty heads (4.2 per cent) while only a single smutted head was found in the entire portion of the field where the seed had been soaked.

Smaller garden plots also were sown with Dakota gray oats which were known to be quite smutty in order to test the disinfecting power of various methods of treatment. At the time of harvesting, samples were taken from each plot and the number of healthy and of smutted heads in each determined as follows:

	Healthy.	*Smutted.*	*Per cent smutted.*
Plot 1.—Untreated seed	1010	106	10 per cent.
" 2.—Seed soaked at 130-5° F., 5 minutes	550	11	2 " "
" 3.—Seed soaked at 135-40° F., 5 minutes	334	0	0 " "
" 4.—Untreated seed	800	51	6.4 " "
" 5.—Seed soaked at 140-5° F., 5 minutes	250	0	0. " "
" 6.—Seed soaked at 130-5°F., 15 minutes then cooled in cold water	260	0	0. " "
" 7.—Untreated seed	570	49	8.6 " "

The disinfecting value of the different methods is evident at a glance. Here again conditions of drainage in the latter part of the summer prevented a just comparison of the yields of the different plots. The germination and early growth gave the following evidence as to the effects of the various treatments:

Plot 2.—Apparently a little better than untreated.

Plot 3.—About equal to the untreated, but not quite so good as No. 2.

Plot 5.—Not quite so good as the untreated.

Plot 6.—About equal to the untreated.

Judging from these experiments we recommend as the safest and best method the soaking of seed oats 15 minutes at temperature 132°-135°, then cooling with cold water.

(*B*) AMOUNT OF LOSS FROM SMUT IN OATS.

Since we have a reliable remedy for oat smut in the proper use of hot water for disinfecting the seed oats, it is a matter of most practical importance to learn just how great is the loss in our oat fields from this disease. As the smutted heads are not very conspicuous after the grain is fully headed the amount of the loss is generally underestimated.

We determined the average loss in all plots at the Experiment Farm in 1890 as about 10 per cent. The average loss about Burlington last summer was considerably less than this as indicated by the results of examinations made in ten oatfields in this vicinity. The samples were taken by placing a frame two feet square in the grain and cutting all plants included by it. The samples were taken from various parts of the field in all cases, and in order to avoid any chance for discrimination the person taking the samples would close his eyes, walk a dozen steps then place the frame over the grain before opening his eyes. This certainly did away with any personal equation.

Field I. Clydesdale oats—seed from Richard Nott, Burlington—Ten samples taken.

Total number heads, 730; smutty, 30; per cent smut, 4.2.

Field II. American Banner—seed from J. M. Vick, Rochester, N. Y.—Five samples taken.

Total number heads, 224; smutty, 0; per cent smut, 0.

Field III. White Minnesota—Four samples taken.

Total number heads, 545; smutty, 13; per cent smut, 2.4.

Field IV. Dakota Gray—home grown seed—50 samples taken.

Total number heads, 4130; smutty, 278; per cent smut, 6.4.

Field V. White Canadian Oats—seed from A. G. Peirce—Ten samples taken.

Total number, 721; smutty, 20; per cent smut, 2.8.

Field VI. Common White Oat—Five samples taken.
Total number, 437 ; smutty 14 ; per cent smut, 3.2.

Field VII. Common White Oat—Ten samples taken.
Total, 634 ; smutty, 21 ; per cent smut, 3.3.

Field VIII. White Oat, variety unknown—Ten samples taken.
Total, 1196 ; smutty, 68 ; per cent smut, 5.73.

Field IX. Common White Oat—Five samples taken.
Total, 484 ; smutty 7 ; per cent smut, 1.46.

Field X. White Oat, variety unknown—Six samples taken.
Total, 525 ; smutty 15 ; per cent smut, 2.86.

Average per cent smut in ten fields, 3.2.

(*C*) WILL IT PAY TO DISINFECT SEED OATS?

Granting that our oat crop is reduced 3 per cent to 4 per cent by the smut, is this amount large enough to pay for the trouble of disinfecting the seed? It is unquestionably a considerable trouble to soak all of our seed oats in hot water as recommended. In order to get a more definite idea of the actual expense of thus treating the seed, 20 bushels of grain were disinfected, all items of expense being noted. An old trough about two feet deep, a kerosene barrel and two wash tubs were the vesels used. The oats to be disinfected were placed in old fertilizer sacks, a bushel in each sack. The trough was large enough so that two of these sacks were immersed at a time. Working in this way it took two men four hours to disinfect 20 bushels, carry them up two flights of stairs and spread them out to dry. As the work was done in the winter it was necessary to keep this drying room heated that the oats might not freeze.

The total cost of the treatment and drying was :

16 hours work at 15 cts	$2.40
300 lbs. coal at $5.75 per ton	.87
Total cost	$3.27
Cost per bushel	.16⅛

We had one advantage in this work that should be mentioned, we were able to heat the water by steam from the boiler of the furnace in the dairy building. It would require the assistance of another man or boy to heat the water upon an ordinary cook stove and work so rapidly.

If 3 bushel of seed be used per acre the cost of disinfecting would be about 50 cents upon the basis of this work. If the yield from the same be 40 bu. of which 4 per cent or about 1½ bu. were otherwise lost because of smut the gain would barely pay for the trouble of disinfecting the seed.

There are at least two important considerations that come into the account here, however.

First—If the smut is destroyed in the seed oats this year the grain from this field will have no smut and this strain of oats can be grown for several years before it will become again seriously affected with the disease. Treating the seed one year then insures an increase of 3 or 4 per cent in each crop for a number of years.

A second and very important consideration is the possible gain aside from and beyond the destruction of the smut. The soaking of the seed in warm water appears to improve its quality in some way not as yet explained. Our fields last summer all seemed to show this. Experiments at other Stations in this country and in Europe all indicate the same fact. An increase in yield of from 5 to 10 and even more bushels per acre, is claimed as due to the beneficial effects of soaking the seed. If this is true will it not pay to soak all our seed oats in hot water for the beneficial effects of the treatment aside from any consideration of smut? Judging from a number of tests of treated seed in green house beds and germinating pans, we believe that the effects of the treatment will be found to vary with different samples of seed, and that the question needs more investigation before we make any absolute statement.

IX. THE EFFECTS OF VARIOUS FUNGICIDAL TREATMENTS UPON THE VITALITY OF SEED CORN.

The advisability of soaking seed corn in some solution to destroy smut-spores that may be clinging to it has been advocated more or less for many years. Various solutions for this purpose have been advocated, a solution of blue vitrol in water being most commonly used. Although effectually destroying smut, blue vitrol solutions have an injurious effect upon most seed grain. The hot water remedy on the other hand promises to be beneficial rather than injurious in most cases, and to be equally effectual as a fungicide against the smut. It seemed advisable to test the effects of the warm water treatment upon the germination of seed-corn. The work was begun in the greenhouse, seed being subjected to following treatments just before planting:

Row 1.—Soaked in water at 130° F 15 min. then cooled in cold water.
" 2.—Untreated.
" 3.—Soaked in water at 140° F 15 min. then cooled in cold water.
" 4.—Soaked in ½ per cent solution copper sulphate 24 hours.
" 5.—Untreated.
" 6.—Soaked in 1 per cent solution copper sulphate 24 hours.
" 7.—Soaked in 6¼ per cent solution copper sulphate 10 hours.
" 8.—Untreated.
" 9.—Soaked in 6¼ per cent solution copper sulphate 24 hours.

Conclusion: (1)—The hot water treatments (1 and 3) both injured the vitality of the seed, the injurious effects of the higher temperatures being quite marked. Of the blue vitrol treatments No. 7 did not injure the seed, all of the other treatments were injurious, Nos. 4 and 6 being somewhat and No. 9 very noticeably injured. It is worthy of note that the vitality of all the seed was low, only 90 per cent of the untreated seed growing. The same line of investigation was undertaken on a much larger scale in the field in the summer.

Two plots were planted, each containing 72 rows, 25 hills in each row. These plots were duplicates except that in plot B, King Phillip corn was used and in plot A, common 8-rowed flint corn. The latter was excellent seed the former not so good, and this fact adds additional interest to the results.

The treatments of the plots were as follows:

Row.	Treatment.
1.	Untreated.
2.	Soaked in water at 100°–105° F. 5 minutes.
3.	" " " " 10 "
4.	" " " " 15 "
5.	Untreated.
6.	Soaked in water at 105°–110° F. 5 minutes.
7.	" " " " 10 "
8.	" " " " 15 "
9.	Untreated.
10.	Soaked in water at 110°–115° F. 5 minutes.
11.	" " " " 10 "
12.	" " " " 15 "
13.	Untreated.
14.	Soaked in water at 115°–120° F. 5 minutes.
15.	" " " " 10 "
16.	" " " " 15 "
17.	Untreated.
18.	Soaked in water at 120°–125° F. 5 minutes.
19.	" " " " 10 "
20.	" " " " 15 "
21.	Untreated.
22.	Soaked in water at 125°–130° F. 5 minutes.
23.	" " " " 10 "
24.	" " " " 15 "
25.	Untreated.
26.	Soaked in water at 130°–135° F. 5 minutes.
27.	" " " " 10 "
28.	" " " " 15 "
29.	Untreated.
30.	Soaked in water at 135°–140° F. 5 minutes.
31.	" " " " 10 "
32.	" " " " 15 "
33.	Untreated.
34.	Soaked in water at 140°–145° F. 5 minutes.
35.	" " " " 10 "
36.	" " " " 15 "
37	Untreated.

Row.	Treatment.
38	Soaked in water at 145°–150° 5 minutes.
39	“ “ “ 10 “
40	“ “ “ 15 “
41	Untreated.
42	Soaked in Bordeaux mixture * 5 minutes.
43	“ “ “ 10 “
44	“ “ “ 15 “
45	Untreated.
46	Soaked in Bordeaux mixture 1 hour.
47	“ “ “ 6 “
48	“ “ “ 5 minutes.
49	Untreated.
50	Soaked in double strength Bordeaux mixture 10 minutes.
51	“ “ “ “ “ 15 “
52	“ “ “ “ “ 1 hour.
53	Untreated.
54	Soaked in double strength Bordeaux mixture 6 hours.
55	“ quadruple “ “ “ 5 minutes.
56	“ “ “ “ “ 10 “
57	Untreated.
58	Soaked in quadruple strength Bordeaux mixture 15 minutes.
59	“ “ “ “ “ 1 hour.
60	“ “ “ “ “ 6 “
61	Untreated.
62	Soaked in 6 per cent copper sulphate solution, —5 minutes.
63	“ “ “ “ “ “ 10 “
64	“ “ “ “ “ “ 15 “
65	Untreated.
66	Soaked in 6 per cent copper sulphate solution 1 hour.
67	“ 12 “ “ “ “ 5 minutes.
68	“ “ “ “ “ “ 10 “
69	Untreated.
70	Soaked in 12 per cent copper sulphate solution 15 minutes.
71	“ “ “ “ “ “ 1 hour.
72	Untreated.

There was no smut upon any of the corn hence the fungicidal value of the various treatments was not determined.

The following are the conclusions reached as to the effects of the various treatments upon the vitality of the seed corn.

1. The King Philip corn was injured by the hot water at a lower temperature than was the 8-rowed corn. This was probably due to the lower vitality of the King Philip corn.

2. With the King Philip corn the hot water treatment was slightly beneficial up to a temperature of 120°. All the hot water treatments above 130°–135° fifteen minutes were injurious, 140°–145° injuring the corn very seriously.

3. With the 8-rowed corn the hot water had less marked effects either beneficially or injuriously; with a few slight exceptions there was no evidence of injury from even the most extreme treatments.

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*Copper sulphate 6 lbs., lime 4 lbs., water 22 gals.

4. Soaking in the Bordeaux mixture for one hour and less had no perceptible effect, and soaking six hours was slightly beneficial.

5. Soaking in copper sulphate solutions of either strength for lengths of time up to 15 minutes had no apparent injurious effect. Soaking one hour was slightly injurious.

X. LETTUCE MILDEW AND LETTUCE ROT.

Lettuce Mildew.—Upon starting the new green house in December, seedling lettuce plants were gotten from Boston. Soon afterward the *lettuce mildew* (*Peronospora gangliformis*, (B.) DBy.) appeared upon them and threatened to do very disastrous work. The house was thoroughly disinfected with sulphur fumes. This entirely destroyed the fungus, not a sign of this disease having been seen since.

Lettuce Rot.—Much trouble and serious loss was experienced however, during the entire winter with the *lettuce rot* both in our own house and that of others in the city. This trouble appeared only in the *head* lettuce varieties, the Grand Rapids and other crinkly leaved varieties not being attacked. There was rarely any sign of disease, until, just as the plants began to head out, the tips of the larger, outer-most, leaves would curl and turn brown at the tips; later the young forming head would die and often rot away. Prof. J. E. Humphrey of the Massachusetts Experiment Station attributes this trouble to the attack of the fungus *Botrytis vulgaris*, Tr. The fruiting fungus was found abundantly upon the decaying leaves, in the more advanced stages of the disease appearing as a dusty grayish mould. This is an extremely hard fungus to destroy from the green-house since it is saprophytic in its habits growing very generally upon decaying leaves or other vegetable matter. Its attack upon the lettuce at the time of heading and not before may be due to the weakened condition of the young plant resulting from the rapid growth at this stage.

XI. VERMONT WEEDS.

There are but few weeds that are hard to keep in subjection where the land is ploughed and used for a rotation of crops. The trouble is much more serious however on the stony hillsides that are used as pastures and which cannot be ploughed. Here the brake, sorrel, hardhack, golden rod, moss, white-top, live-for-ever and raspberry are hard to keep out.

Believing that it would prove of practical value as well as of interest to learn what weeds are most troublesome in different portions of the State, copies of a list of the more common weeds were sent or handed to a number of farmers, chiefly through the aid of the State Board of Agriculture, with the request that each farmer check upon this list the names of the ten weeds he found most troublesome, placing a 1 before the one he considered worst, 2 before the next worst, etc. Forty marked lists have been returned up to date. While the entire State is not fairly represented in these replies, it is hoped to get further information, and it will be of interest to publish these results as preliminary to further inquiry.

In order to make the matter as easily comprehensible as possible these results are placed in tabulated form. A little explanation will make the table more clear. Since various names are given to the same plant in different neighborhoods a list of these various names is given in each case. The last ten names were not on the original list; if they had been they would probably have received more votes.

Following each name is a statement of the ranks given it in the various reports, thus for the Daisy: in three reports it was given 1st place (as worst) in five it was placed 2d, in four it was 3d, etc. The total number who checked the Daisy in their lists is given in the last column as 24. Considering both the number of the votes and the rank given, the worst ten according to these reports, would be 1 quack grass, 2 white daisy, 3 kale, 4 live-for-ever, 5 hawkweed, 6 lance-leaved plantain, 7 wild carrot, 8 brake, 9 yellow dock, 10 Canada thistle.

COMMON NAME.	BOTANICAL NAME.	Relative Obnoxiousness.											Total No. Votes.
		1 st.	2 d.	3 d.	4 th.	5 th.	6 th.	7 th.	8 th.	9 th.	10 th.	above 10th.	
Oxe-eye Daisy, White Daisy	Chrysanthemum Leucanthe-	3	5	4	1	3	2	1	0	3	2	0	24
	mum, L.	2	4	1	2	2	0	1	0	1	2	0	15
Wild Carrot	Daucus carota, L.	2	2	3	3	2	2	2	3	2	2	1	24
Kale, Charlock, Wild Mustard	*Brassica Sin'trum, Boiss.												
Ragweed, Roman Worm-wo'd	Ambrosia artemisiaefolia, L	0	1	3	1	1	3	1	2	0	2	1	15
Hawk-weed, Ladies' Paint Brush	Hieracium aurentiacum, L.	4	0	0	0	1	1	0	2	6	0	1	10
Quack, Knot-grass, Witch-Grass	Agropyrum repens, Beauv.	7	0	2	3	2	2	0	1	2	0	0	19
Pigweed, Hog-beet, Green Amaranth	Amarantus retroflexus, L.	1	1	1	2	0	2	2	1	1	1	1	13
Lance-leaved Plantain, Rib-grass, English Plantain	Plantago lanceolata, L.	2	4	2	2	1	0	2	1	1	2	1	18
Pigweed, Lamb's quarters, Goose-foot	*Chenopodium album, L.	0	1	0	0	2	1	0	2	0	2	0	8
Purslane, Pusley	Portulaca oleracea, L.	0	2	1	2	4	1	1	0	2	2	2	18
Sheep Sorrel, Red Sorrel	Rumex acetosella, L.	1	1	4	1	0	1	1	1	3	2	2	17
Chicory	Chicorium Intybus, L.	3	1	1	2	0	0	1	0	0	1	1	9
Shepherd's Purse	CapsellaBursa-pastoris, Moench	0	0	0	0	0	0	1	1	0	0	1	3
Canada Thistle	Cnicus arvensis, Hoff	0	3	2	2	3	0	2	4	2	3	0	21
Yellow Dock, Curled Dock	*Rumex crispus, L.	1	1	1	1	3	2	1	2	5	2	1	20
Pigeon Grass, Fox Tail	*Setaria glauca, Beauv.	0	1	0	0	0	3	0	1	1	1	0	7
Barn-yard Grass	Panicum Crus-galli, L	0	1	4	1	0	0	0	0	2	0	2	10
Crab Grass, Finger grass.	Panicum sanguinale, L	0	0	0	1	0	0	0	0	1	0	0	2
Burdock	Arctium Lappa, L.	0	1	1	0	1	3	0	2	6	1	2	17
Chickweed	*Stellaria media, Sm.	0	0	0	0	1	1	1	0	2	1	1	7
Mallow, Cheeses	Malva rotundifolia, L.	0	0	0	1	1	0	0	1	0	1	1	5
Brake (in dry pastures)	*Osmunda cinnamonea, L.	2	1	4	1	3	1	2	1	3	0	0	18
Fern (in wet meadows)	*Onoclea sensibilis, L.	0	0	1	0	1	1	1	1	0	0	1	6
Wild Sun-flower, YellowDaisy	Rudbeckia hirta, L.	1	1	0	0	1	0	1	0	2	3	0	9
Pitchforks, Sticktights	*Bidens frondosa, L.	0	0	0	0	0	0	0	1	1	0	1	3
May-weed	Anthemis cotula, Dc.	0	0	0	0	0	0	0	0	0	0	0	0
Hardhack	*Spiraea tomentosa, L	0	2	1	3	2	1	1	0	1	0	0	11
Golden Rod	Solidago spp.	0	1	3	1	0	0	0	4	2	2	2	15
Moss, Hair-cap	*Polytrichum commune	0	1	0	1	0	2	1	1	0	3	0	9
Wild Parsnip	*Pastinacea sativa, L.	0	1	0	2	1	1	1	1	1	2	1	11
Toad-flax, Butter and Eggs	Linaria vulgaris, Moen.	0	0	0	0	0	0	0	0	0	0	0	0
Sow Thistle	*Sonchus oleraceus, L.	0	1	0	0	0	0	1	1	0	1	0	4
Wild Morning Glory, Bind-weed	*Convolvulus sepium, L	1	1	0	0	0	0	0	1	1	0	0	4
Wild Buckwheat, Black Bind-weed	*Polygonum convolvulus, L	0	0	0	0	1	1	2	1	1	0	0	6
Live-for-ever	*Antennaria pl'folia, Hook.	4	1	0	0	2	4	1	0	0	3	2	17
White Top, Wild Oat Grass	Danthonia spicata, Beauv.	1											1
Wild Bergamot	Monarda fistulosa, L.											1	1
Milkweed	*Asclepias Cornuti, Dec											1	1
Smartweed	*PolygonumHydropiper, L.											2	2
Buttercup	Ranunculus acris, L.							1					1
Blue Thistle	Echium vulgare, L.											1	1
Raspberry	*Rubus strigosus, Mx.						1						1

*This is the most common species, but other closely related plants are known by the same common name,

REPORT OF THE ENTOMOLOGIST.

G. H. PERKINS.

THE WHITE GRUB.

A study of the life history of Lachnosterna and of remedies against its attacks.—Few of our common injurious insects have been so long known, so often more or less fully described and so imperfectly understood, as has the May Beetle and its larva, the White Grub. This insect is often mentioned in the writings of the earlier entomologists of this country and has been time and again described, figured and discussed in later reports and all of these have contained erroneous statements and have never presented anything like a complete life history of the insect. Even now an absolutely complete life history can not be given of most, if of any, of the numerous species which are included in the genus *Lachnosterna.* Recent observations have added much to our knowledge of the genus and removed much error, and the study of remedies by which the larvæ may be destroyed, or at least held in check, has not been without substantial results. It is well to state that there are good reasons why our knowledge of the beetle and grub has hitherto been so imperfect and that it is not wholly due to carelessness or inefficiency on the part of observers. The names of some of those who have given accounts of it are evidence that this is not true, but, rather, it is because the habits of the beetle in its larval and adult states are such that they have not readily been discovered in all their details. Only continuous, patient, careful and prolonged observation could decide many questions that the history of this insect called up and many persons otherwise well equipped to answer them were obliged from lack of time to leave them unanswered.

The time and labor involved in working out the life history of any single insect may be very considerable and the insects are many while the laborers are few. Yet it is obvious that the first condition of success in fighting any injurious insect must be a knowledge of its habits, transformations, and all that makes up its biography from the beginning to the end of its life. Without this knowledge all efforts at extermination are of little avail, for we are working in the dark and at random; we may hit and we may as easily miss the foe at which we strike, but with this knowledge our efforts must be far more successful, if not completely so.

The writer must in all honesty confess his own faults respecting the *White Grub.* In the Second and Fourth Reports of this Station and in several of the Reports of the State Board of Agriculture, he has spoken of this insect and has in the main repeated the mistakes of all other entomologists. It is partly because of this and partly because the observations of the past year have enabled him to correct some of his former errors and partly because the insect continues to be one of the most injurious found in Vermont that he again calls attention to it. In the first place we have all along spoken of *the* May Beetle and *the* White Grub, but the singular must be henceforth dropped, for our former single species proves to be several. Here in Vermont we have at least six species and probably more. The mistake of confusing several species and calling them all one is quite excusable, for the species resemble each other very closely, so that even an experienced entomologist may not always be sure of his identifications and until Dr. Horn's "*Revision of the Species of Lachnosterna of America, North of Mexico,*"* it was scarcely possible for even a trained entomologist to distinguish and arrange those species of the genus which he was able to collect in his own locality. Dr. Horn instead of the few species previously recognized, separates the genus into eighty-one species most of them, however, not found in New England.

The publication of the above monograph by Dr. Horn shed new and greater light upon the perplexing questions arising from a study of the genus. A year or so later the work was carried still further by Prof. J. B. Smith in "*Notes on the Species of Lachnosterna,*"† who recognizes eighty-seven species. Thus far less than a dozen of these have been found in New England, although I have no doubt that investigation will disclose many others. Prof. Smith adds a very important group of characters by which the species of the genus may be separated and in many cases more surely and readily than by any other, namely, those pertaining to the genital apparatus of both males and females, especially of the former.

By the aid of these two papers the student of the genus *Lachnosterna* may, with at least tolerable certainty, work out his specimens and there is no longer the excuse which has existed for confusing under one form a number of clearly distinct forms. Though not of immediate and apparent practical value, these revisions and elucidations of the genus are indirectly of the highest practical importance, for the first step towards such a full knowledge of a group of insects as will make it possible to administer remedies successfully is almost always a clear determination of the species in question. Hence Dr. Horn and Prof. Smith deserve, as they will undoubtedly receive, the hearty thanks not only of entomologists, but also of all interested in agricultural pursuits.

It were little less than arrogance perhaps to assume to correct all previous errors which are to be found in descriptions of *Lachnosterna* and nothing so complete as this is promised, but the writer hopes that some inaccuracies may be removed and some facts established. Until recently all writers have declared that the *Lachnosterna* larvæ, the White Grubs, complete their growth in the spring or early summer and then in a short time change to beetles. Our observations show very conclusively that this is not true but that the larvæ get their full growth during the early summer, enter the chrysalid state and emerge as perfect beetles late in the summer or early in the fall. They remain more or less dormant during the winter in the ground, a few coming from the ground in the fall, but most, not until the following spring. The eggs are laid in spring and the beetles die in early summer. In the Second Report of this Station, published in 1888, the writer called attention to the fact that the beetles appear in autumn, "from September till after the first of November" and, so far as he is aware, this is the first published statement of the fact. My opinion then was that while many, or even most of the larvæ pupated in the late summer, some remained until spring in the larval condition. Even now I am not sure that this is not the case. In *Insect Life* * and much more fully in his Sixth Report as State Entomologist of Illinois, Prof. S. A. Forbes has published an account, which should be regarded as the first correct statement of the life history of *Lachnosterna* and one that must replace all that have preceded it. Prof. Forbes on page 31 of the above Report remarks as follows: "In fact all the species of *Lachnosterna* whose transformations I have observed get their full growth in spring and early summer, pupate in summer and early autumn, change in the earth to the adult beetle in the fall and hibernate there in that stage without escaping, finally crawling out of the earth for their brief life as June beetles in April, May or June, or rarely in July."

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*Transactions of American Entomological Society, vol. xiv, page 209.

†Proceedings of U. S. National Museum, vol. xi, p. 481.

The present writer's observations agree with this statement except that, as has been seen, a few of the beetles do crawl from the ground in the fall. It also appears to be true that some of the larvæ do get their full growth in the fall and do not materially change after this, until the time of pupation the following spring.

Further facts in the life history of *Lachnosterna* will appear in what follows:

EGGS.—The time and place of depositing the eggs have never been certainly known, though we may be pretty sure that Prof. Riley's statement † is substantially correct. "Soon after pairing the female creeps into the earth, especially wherever the soil is loose and rough, and after depositing her eggs, to the number of forty or fifty, dies." In his Fifth Report, page 55, Prof. Riley describes the eggs as "white, translucent, spherical, with an average diameter of .09 inch. They are deposited between the roots of grass, and are enclosed in a ball of earth, evidently formed by the ovipositor of the female before deposition, as the cavity is sufficiently large for the egg to roll about in."

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* Vol. III. page 239, 1889.

†First Missouri Report p. 157.

So far as I am aware no further light was thrown upon this matter until the publication of Prof. Forbes' paper already mentioned. Several specimens of *Lachnosterna inversa* were captured and placed in breeding cages and these began to lay eggs on the fifth of June. These eggs were "oblong oval when first deposited, but soon swelled to a spherical form. They were deposited singly in the earth, each in a separate cell barely large enough to contain it. At this time the males began to die and by the middle of the month the females were also occasionally found dead, always with spent ovaries. By June 21st the larvæ were well developed within the egg, and on the 23rd the first one hatched."* Prof. Forbes also found eggs of *Lachnosterna hirticula* on the 28th of June from which larvæ hatched July 7. It is probable that other species of the genus would differ but little in their life history.

LARVÆ.—January 28th, 1891, fifty larvæ were dug from sandy soil on the College Campus in Burlington. As there had been for some time a foot or more of snow covering the ground it was, in most places, quite free from frost and the larvæ were apparently as active as in summer. Some were within three inches of the surface, and they were found at all depths below this to eighteen inches. They were for the most part in the same curved position that they usually take when feeding. The larvæ found at this time were nearly equal in size and appeared to be full-grown. About half of the larvæ were placed in a box of sandy soil which was kept in a greenhouse for future observation.

Early in March a second lot of larvæ was dug. These were found in much the same condition as those first obtained. A few days later a third lot was collected. At this time larvæ of three distinct sizes were found. The ground was now frozen in places and some of the larvæ were taken from almost solid clods, but most of them did not appear to be injured, though some had turned black and were evidently dead. Upon the legs of several of this last collected lot of larvæ were mites which appeared to be parasitic. They were active and in good condition. Several were saved for identification, but were accidentally lost. I think, however, that they were of either the genus *Tyroglyphus* or *Rhizoglyphus*. The mites were found only upon the legs of the White Grubs and as many as eight or ten were seen upon a single leg. The larvæ did not appear to be weakened or in anyway affected by the mites. In the collections made previously no beetles had been found but at this time several were discovered.

On April second, larvæ were again dug. No mites were found upon these, but several were infested with the fungus *Cordyceps ravenelii* which had exidently been growing for some time. Some of the fungi were an inch and a half or two inches long. The grubs were of course destroyed. A portion of them were replaced in the ground in order that the fungi might develop and produce spores which would infest other grubs. As will be seen later, there is much to hope for from the attack of this fungus, for it not only is destructive to the White Grub, but to wire worms and probably it may readily infest other subteranean larvæ. In addition to the collections of larvæ enumerated, other lots were obtained at intervals until mid-summer and specimens from each lot were kept for observation in boxes of earth covered with sod.

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*Sixth Report p. 39.

As we have seen, three distinct sizes were noticed in the larvæ and in one case four. The three common forms may be very briefly characterized as follows:

The length of the larger form when fully grown is about an inch and a half (1.4-1.6 inches) with a diameter in the thoracic region of rather less than half an inch. The color is yellowish white, the head light chestnut as are the legs, maxillae, mandibles and spiracles. The terminal segment is more thickly sprinkled with bristles than the rest of the body over which they are sparcely scattered, and it is not usually so much swollen as represented in some of the published cuts.

The medium larvæ are about an inch long and 0.3 inches in diameter in the thoracic region. The general characters are somewhat as above, but the color of the body is less yellow and the dark parts as the head are lighter. The line of the intestine is more distinct in the full grown larvæ.

The small, or youngest, larvæ differ from the above mainly in being of a clearer white color and more active in their movements. The length is 0.6 inch, width 0.23 inch.

Altogether several hundred larvæ were collected at the times above mentioned and placed in the boxes where they could be watched. They continued in excellent condition throughout the summer but with two exceptions showed no indication of pupation until September. These two made cells and pupated early in May. The rest were all changed to beetles by the last of September. There was no appreciable change in size or appearance of the large larvæ during the summer, although as they were supplied with turf, they did not lack food. On the whole, I should think that the percentage of larvæ pupating in spring or early summer, as most of the accounts assert, is very small. Probably the specimens herein mentioned, inasmuch as they were taken from the cold ground for the most part in early spring, completed their development earlier in the fall than they would have done if left out of doors.

The different sizes of larvæ found would indicate that the often stated time of growth, three years, is correct, though I am inclined to suspect that sometimes the development extends to the fourth season.

THE BEETLE.—Thus we see that the insect hibernates in three ages of the larval state and also in the adult or beetle state, but the beetles are sluggish until spring when they appear in greater or less numbers. As to the periodicity of their abundance or scarcity, I can not as yet speak positively. If the larvæ finish their growth the third season we might expect a greater abundance every third season. Though this would not necessarily occur, for it is certainly possible that about the same number of eggs may be laid each year and about the same number of larvæ transform into beetles. But it is very evident to any one who has studied the insect that it is much more abundant during some seasons than during others. I do not, however, think that this is regular and that, in this region at least, the abundant seasons are triennial. The present season, 1892, is one of unusual abundance, while last year the beetles were unusually scarce, but the year previous to this, 1890, was one of abundance.

The first beetles appear usually about the first of May, but, unless the season is unusually early, they are not at all abundant until the middle of May or even later. After the middle of May the numbers increase until after the first of June, when usually there is a decrease. Few are seen after the last of June until the new brood makes its appearance as a few stragglers in September, October or even November. These last probably all perish from cold, some certainly do.

The common species here are *L. dubia*, Smith, and *L. fusca*, Froh. Very much less common are L. *grandis*, Smith, *L. arcuata*, Smith, *L. insperata*, Smith, *L. rugosa*, Mels. Usually more males than females were taken.

Early in the season in this region, *L. dubia* is most abundant, later *L. fusca* appears and soon becomes about equally abundant with *dubia* so also in the fall these two species appear about equally. The other species I have thus found only during the period of greatest abundance. There is here, as elsewhere, a large and a small form of *L. fusca*, As most of my observations have been made in the immediate neighborhood of Burlington, and as no others, so far as I can learn, have been made in other parts of the State it may be regarded as well nigh certain that additional species will be discovered in Vermont when more extensive investigations have been made.

EXPERIMENTS WITH VARIOUS SUBSTANCES USED TO DESTROY THE WHITE GRUB.

While the above observations upon the life history of the White Grub were being made, other observations and experiments were carried on with the hope of discovering some cheap and efficient agent which would destroy the grubs without injuring the vegetation upon which they feed. Only abstracts of these experiments need be given at this time since a full account of the many experiments which were made would be tedious and is not necessary. In most cases the average results of many experiments is that given rather than single experiments.

Experiments with the Fungus Cordyceps.—It will be remembered that quite a number of the larvæ dug early in April were infested with *Cordyceps ravenelii* or the *White Grub fungus.* None of the fungi showed complete development, but it was hoped that if placed in earth they might complete their growth and produce spores.

A number of infested grubs were placed in a box of earth with a large number of healthy ones, but, as the fungi did not produce spores, nothing came of this attempt. I fully believe, however, that this fungus may be used to great advantage in attacking the *White Grub* This opinion is confirmed by an article in *Comptes Rendus,** by M M. Prillieux and Delacroix in which attention is called to experiments made with a parasitic fungus which is found on *Melolontha vulgaris* or the European May Beetle, an insect closely allied to our May beetle. Larvæ infested with this fungus are covered with tufts of short white filaments. When such larvæ are replaced in the damp ground, the mycelium completely fills their bodies and the fructification appears on the surface as "little hemispherical masses" which are pure white and produce minute spores. According to the authors named, the fungus is *Botrytis tenella,* Saccardo. By cultivating the spores and diluting the culture with water, these gentlemen obtained a liquid which, when poured upon soil infested with White Grubs, so infected them that in two weeks all were destroyed. M M. Prillieux and Delacroix conclude by saying,—I give a free translation,

"It is established by these investigations :

1st. That *Botrytis tenella* is the real parasite which attacks in the soil the larvæ of the May beetle.

2d. That this parasite can be easily cultivated * * * in certain nutritive media.

Third, That spores obtained from these cultures and poured upon the soil cause the death of the larvæ which may be in it without injuring the vegetation.

In addition to the above we find that in the number of the *Comptes Rendus* from which the above quotation is taken M. Le Moult, who in 1890 first called attention to this fungus, gives with some detail experiments carried on in the field which were exceedingly successful in destroying the larvæ of the European May Beetle. Lawns in which the grass had been completely destroyed by the grubs were wholly freed from them by the use of the fungus and M. Le Moult declares his belief that the fungus will not confine its destructive effects to the larvæ, but will attack the insect in all stages of growth. While it is necessary to remember that these results have been obtained in Europe and with the European not the American insect yet the similarity in habit and structure which exists between them is so great that we may well hope for similar results from similar causes on this side of the Atlantic.

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*Vol. 112, page 1079, May 11, 1891.

This hope is rendered stronger because by some authorities *Botrytis*, or as it is by some named, *Isaria*, (M. Giard regarding it as most probable that in the latter genus is the true place of the fungus rather than the former) is believed to be the conidial stage of *Cordyceps*, and if this is the case we have every reason to believe that in this plant we have a true destroyer of our own White Grub which *Cordyceps* does attack. M. Giard very pertinently remarks, after having given a list of insect-destroying fungi, that all those named are more or less unknown in some of their stages and that the determination of species should be made with not a little reserve.

In *Insect Life*, November 1891, there is a note stating that culture tubes of the fungus are offered for agricultural use. The contents of one of these tubes are to be sprinkled over a hundred White Grubs which are then to be buried in damp soil. In six hours these grubs may be regarded as infested when they are to be placed here and there in the ground where the uninfested grubs are doing mischief so that from them all may be infected and destroyed. These statements are given because it is my opinion that of all remedies which have been devised against the White Grub the fungi are most likely to be successful.

Effect of Cold.—In order to ascertain the effect of severe cold a number of larvæ confined in a few cubic feet of earth were placed out of doors in January and after a week examined. During this time the thermometer was continually below freezing, but never below zero F. All of the grubs were black and dead at the end of the week. Other trials resulted in the same way showing conclusively, it would seem, that a freezing temperature is fatal to the grub as, considering its juicy soft structure, we should suppose would be the case. Yet there is some question as to this for as we have seen, some of the grubs dug from frozen ground in March were not, to all appearances injured although others were. Hence we can not state positively that exposure to a temperature of 32° F. is invariably fatal to the grubs although there is, I think, no doubt that this is generally so.

Effect of Hunger.—Several able entomologists have recommended starvation as a remedy for White Grubs. That is, they advise a removal from infested ground of all vegetable matter so far as possible. The practicability of this was tested in various ways, but all with the same result. In some cases sand much more free from organic matter than would exist in any field used for growing crops was taken and grubs confined in it for weeks and in some cases for months, but in no case were they starved. Larvæ of all ages were used in these tests and the result was sufficient to convince me that it is quite useless to attempt any serious injury to the grubs by letting land lie fallow or that there is any feasible way of starving them.

Effect of Moisture and Dryness.—The effect which the condition of the soil produces was thoroughly investigated especially with reference to the amount of moisture. So long as the soil is moderately damp the grubs did not appear to be very much affected by increase in moisture and they were able to thrive, for some time at least, in a very wet soil even when so wet as to be soft mud. If on the other hand the ground is dry the grubs at once show signs of discomfort and if the dryness continues the grubs all eventually shrivel and perish. This effect of drought is very prompt and sure. Hence a wet season would not be injurious to the grubs while a dry season would be unfavorable to them and if a meadow or field infested by them were ploughed during a very dry time many would probably perish, though many would make their way down to the moisture beneath. So long as the soil does not become really dry it is quite habitable to the grubs although the conditions may vary greatly.

Effect of Potash Salts.—A long series of experiments were conducted for the purpose of ascertaining if possible whether some substance could not be profitably used which should act at the same time as a fertilizer to vegetation and a destroyer of the grubs. It was thought that perhaps some one or more of the potash salts commonly used as fertilizers might prove to meet these conditions. The results of the experiments were not altogether satisfactory since it was found that, while some of these salts did prove in a measure destructive to the grubs and of course would be in most cases beneficial to the crop growing in the soil, it was necessary to use a larger quantity than could profitably be applied. Earth saturated with solutions, one ounce to one pint, of *High Grade Manure Salt* did not seem at all unpleasant to the grubs and even when the solutions were poured directly upon the grubs they did not mind it.

Sulphate of Potash, however, gave better results. This salt applied in solution at the rate of 5 pounds to 100 square feet of surface killed half of the grubs in less than twenty-four hours and more died later. The experiments with this salt showed conclusively that if used in sufficiently strong solutions, that is about a pound to two gallons of water, it would destroy at least a considerable portion of the grubs.

Kainite used in the same manner as the Sulphate of Potash was less efficient for while in all cases the Sulphate destroyed more than half the grubs the Kainite did not destroy more than a third. Both these salts were practically useless in weak solutions.

Muriate of Potash gave very much the same result as did *Kainite.*

Common Salt. This was applied in various ways to the soil. Dry salt mixed with the surface soil of a large box containing grubs, at the rate of one ounce to each square foot did not produce much effect. A few larvæ were killed but most remained uninjured. Salt dissolved in water, 1 ounce to 1 pint, did not affect the grubs.

Wood Ashes even when used abundantly failed to injure the grubs, neither did strong lye poured over the ground appear to affect them.

Bisulphide of Carbon. This substance was used in many differently conducted experiments and always with good results. When one ounce of bisulphide was poured into two holes a foot apart the larvæ for some distance around the holes were more or less affected and many killed, while of those not immediately destroyed few recovered.

In *Insect Life*, vol. 3, page 483, the use of capsules of bisulphide is mentioned. These capsules each contained five grains of the liquid. They were placed three feet apart and six inches below the surface in a badly infested lawn, and, while no injury was done to the vegetation, the grubs disappeared. It appears certain that bisulphide of carbon may at least in many instances be used very successfully as a remedy against the White Grub.

Kerosene Emulsion. None of the substances tested proved on the whole, economy and efficiency being taken into account, so satisfactory as kerosene emulsion. Emulsions prepared according to several different formulas were used with no very marked difference in the results and all were efficient.

In 1888 experiments with kerosene emulsion were very successful in Washington, according to an account in *Insect Life*, August 1888, and although the grubs which were destroyed were not the ordinary White Grub yet they were similar and the editorial comment that the common white grub would unquestionably be affected in the same way is fully established by subsequent experiments. Not all the grubs were in any of our experiments destroyed, but more than half of them were, and the grass or other vegetation was not injured. Even when the emulsion was very largely diluted so that it contained only one-twentieth part of kerosene it was effective.

Ants. These insects proved very formidable enemies to the White Grub. If a box containing the grubs was left where ants could get access to it they made very thorough work of them, killing and devouring every one. The species of ant most often seen was the common red ant, though other species attack the grubs. I think that ants deserve more credit for destroying earth inhabiting larvæ than they usually receive.

Frogs. In *Insect Life*, volume II, page 195, Prof. Hargitt mentions frogs among the enemies of the White Grub. I am able to corroborate this statement for in our use of frogs for dissection in the biological laboratory we have often found the stomach full of May beetles. I do not know that we have ever found the insect in the grub state but the mature beetles are common and indicate that frogs are not allies to be overlooked in our warfare against these as well as other insects. We have found as many as ten beetles in the stomach of a single medium sized frog. Toads are also useful in the same way.

Other Enemies. Racoons, as noticed in a former paper, often do great service in destroying both beetles and grubs,rooting them out of the ground when they do not find them on the surface. Skunks, moles, mice, also devour them. Among birds there are many which destroy them. Probably all of the larger insect eating birds eat the beetles and grubs, especially active are crows, blackbirds and robins.

It is evident that our efforts to destroy, or at least to keep in check the May beetle must be mainly directed to the immature state, the white grub. The beetles can hardly be successfully dealt with to any large extent. As they feed upon the foliage of the trees about which they swarm during the warm, still evenings in May, it is quite possible that spraying with Paris green would be of some use although I should not expect great results from this. There are several parisitic insects which serve to keep the White Grubs in check, but in this part of the country I do not think that their attacks are of great importance. The beetles may be collected during the night to some extent by placing a light in the midst of a tub of water, but this and several other and similar traps I have not found very successful and I doubt whether any very practicable method of exterminating them can be devised. It is, however, different with the larvæ, the White Grubs. To exterminate or even check materially these is not easy for, like all other larvæ that live in the ground, they are protected by their habit of life from birds and many other foes which aid in keeping many species from becoming over abundant. Nevertheless, as we have seen, the underground life of the grubs exposes them to some attacks which would not come to them elsewhere and probably the fungus which destroys them now and then is most effective and deadly. Emulsions and other insecticides may also be advantageously used as we have already noticed. In time of drought if the infested land could be ploughed and still more thoroughly dried and if in addition swine or poultry could be turned into the field, many grubs might be destroyed. It is well, whenever the opportunity is offered, to use any means which appear to be efficient in checking injurious insects, even if they are not the best that may have been devised, but of course as soon as practicable the better remedy should be applied. More extended investigation is needed of insecticides and of other means which may be used for the destruction of the White Grub, but much has been discovered in times gone by and we may reasonably look forward to a time near at hand when the depredations of this and other similar pests will be well nigh wholly prevented.

INSECTICIDES.

In previous papers various substances and compounds used for the destruction of insects have been mentioned and the reader is especially referred to the Third Annual Report of this Station page 154, and the Eleventh Report of the Board of Agriculture for information upon this subject. It is not designed to repeat what has been given in the above articles, but there are some additional facts which may find place here. Gardeners and farmers need not be told that no single substance or mixture is better than all others as a remedy for all insect attacks and yet, with Paris Green and kerosene emulsion, one is pretty fully equipped to resist successfully the depredations of nearly all those injurious insects which are likely to attack his crops. New insecticides are continually advertised, but it is always the wisest course for the farmer to refrain from making much outlay upon any of these until they are tested. Many of these are either of no value or, at most not so good as older and well known compounds.

Not only is it desirable that an insecticide that is really efficient be used and that it be used at the proper time, but that it be used in the proper way. Several instances which have recently come under my notice illustrate this latter point. Sundry trees had been sprayed to prevent the injuries done by codling moths. A portion of each tree was, to all appearance, unsprayed while a portion was evidently dosed with too strong a mixture so that the foliage was seriously injured, some of the leaves being destroyed and all more or less blackened. In this case the proper insecticides had been used, at the proper time and in proper quantity, but the very simple precaution of keeping the liquid stirred had not been regarded and a portion of the spraying had been carried on with the upper portion of the liquid which was too weak while the rest of the tree received the mixture from nearer the bottom which was too strong. Although the arsenites have been so long and so extensively used there are some people who do not realize how very readily the London purple, and especially the heavier Paris green, settle to the bottom of a pail of water and how very constantly it must be agitated. On this account the knapsack spraying outfit is exceedingly useful.

So far as injury to the foliage is concerned I have found, as the results of a considerable number of experiments, that up to one pound to 180 gallons of water the arsenites may be used withont injury upon all of our fruit and shade trees, and I have used for the sake of experiment as strong mixtures as one pound to 100 gallons without material damage to apple or shade trees, but this is stronger than is ordinarily necessary. For most purposes the mixture of one pound of either arsenite with 180 or 200 gallons of water, being careful to keep the mixture of uniform strength, is sufficient and in this proportion it can be used on almost any tree, shrub or plant without damage. Of the many forms of nozzle which are offered for sale I like the Vermorel rather better than any other though it is more likely to clog than some. Any nozzle that gives a wide spread and finely divided spray is good. The person who is dealing with injurious insects needs to keep constantly in mind the difference in effect of different poisons. Some destroy by contact, some by their effect when eaten, and to this latter class the arsenites belong. Hence they are of no value except in case of leaf eating insects or those that feed upon some portion of the plant or tree which can be poisoned by the spray. For this reason it is important that the leaves, if these are the object of attack by the insect, or the fruit, if this is what the insect seeks, should be as completely covered with the poisonious liquid as possible so that some of it may be sure to be eaten. For many purposes spraying with the arsenites has been proved to be thoroughly efficient.

The question has been often asked whether the grass under sprayed trees is dangerous to stock feeding upon it. I have not made any experiments to determine this, but experiments have been made, both by allowing stock of different kinds to eat grass from beneath trees that had been thoroughly sprayed and by analysis of the grass. The uniform result of such experiments has been that the amount of poison received by the grass from the dripping trees was much too small to affect stock. As used upon potatoes the mixture is much stronger than that ordinarily used for spraying and this has been seriously injurious to stock eating grass that had been carelessly sprinkled. Prof. A. J. Cook writes as to this, "I sprayed a large tree over some bright tender grass and clover, I then cut the clover carefully, close to the ground and fed it all to my horse. It was all eaten up in an hour or two and the horse showed no sign of injury. This mixture, remember, was of double the proper strength, was applied very thoroughly, and all the grass fed to and eaten by the horse. This experiment was repeated with the same result." Similar experiments have been made with the same result with swine and sheep.

It is well to remember that insects are poisoned by the mixture, and that where bees visit the trees all spraying should be delayed until the blossoms have wholly fallen. It need scarcely be said in addition that no harm can possibly come from using the fruit of sprayed trees.

Kerosene Emulsion.—This in one form or another is one of the very best "all around" insecticides which has ever been discovered. I use the term in the singular for, although there are several formulas, notably two, by which the emulsion can be produced, the effect of all is about the same.

In some quarters there has been considerable discussion as to the respective merits of the Hubbard-Riley formula, and that advocated by Prof

A. J. Cook. It is not my desire to take part in any discussion. I have had no trouble in making and using emulsions prepared according to either formula and prepared by formulas different from either. Inasmuch as the amount of kerosene, which of course is the active ingredient in the dilute solution as finally prepared for spraying, is about the same in each case, I do not see very much difference, although the formulas appear very different. I think that in careless hands the Cook emulsion would be safer, and that the Hubbard makes a more solid and more easily kept compound. As would be anticipated the effectiveness of one does not differ appreciably from that of the other, at least such has been my experience. These formulas have been often published, but as I am continually applied to for them it may be worth while to repeat them here.

The Hubbard-Riley formula is :

Kerosene	2 gallons.
Water	1 gallon.
Bar soap	½ pound.

The soap is to be dissolved in boiling water and when the solution is complete and *boiling hot* the kerosene is added and at once and continually churned for perhaps ten minutes. The result when cool is a solid tallow-like mass which will keep indefinitely though I think it is better to make only what is needed for a single season since, unless very thoroughly corked up, the emulsion dries and becomes hard during the winter and does not readily dissolve in water. The above is, when used, to be diluted with from ten to fifteen times its bulk of water thoroughly dissolved and sprayed or sprinkled over the infested plants. Even when diluted with twenty times its bulk of water, this emulsion is effective against tender bodied insects such as plant lice, while others as bark lice need the mixture twice as strong. The general opinion of those who have used the emulsion is that about twelve times diluted it does well in case of most insects. It is also excellent as a wash for domestic animals infested with lice, ticks or fleas. It is better than most substances for maggots, the solution to be poured about the infested roots, so as to reach the maggots. Unlike the arsenites the emulsion is not a poison and kills only by contact with the bodies of insects. This is an advantage in some cases and a disadvantage in others. The insects do not eat it, or are not destroyed by that means. Leaf eaters and such insects as the codling moth can best be dealt with by arsenical spray, but this is not very effective against plant or bark lice and any others that do not eat such parts of plants as can be sprayed. These can much more effectively be destroyed by dilute emulsion.

The Cook emulsion is made as follows :

Kerosene	1 quart.
Water	1 gallon.
Bar Soap	½ pound.

or it can be made by using, instead of bar soap, 1 pint of soft soap and for bark lice or for washing animals I think the soft soap emulsion is preferable. This emulsion is to be made in the same manner as the other. In making small quantities I find a common greenhouse syringe most convenient for churning the mixture after adding the oil. For larger quantities a force pump may be used. When used the above is to be diluted with ten quarts of water.

Potash Salts—Kainite, Muriate of Potash, Sulphate of Potash.—In addition to what has been said of these salts on preceeding pages it may be noticed that either of them in solution is excellent where the ground is infested with the common garden slug, *Limax Campestris, B.* If the ground about plants is well sprinkled with a moderately strong solution of the salt, 1 ounce to 1 pint of water, it will be avoided wholly or at least to a great extent by slugs and thus the sometimes annoying depredations of the mollusks prevented, while of course the soil will be in all probability improved by the application. It is said by some entomologists that washes of the potash salts are useful in ridding trees from scale lice.

It is also asserted that these salts have been used in corn hills, placed with the corn when planted, as a fertilizer, with excellent results to the corn and disastrous results to cut worms and wire worms. My own experiments are not very conclusive in these last matters, but so far as they go they do not confirm the above. However these salts are worth trying for they certainly are good fertilizers and may do something in the way of keeping off insect pests.

Naphthaline.—This substance, sometimes called coal tar camphor, is a white or pinkish solid, with a very decided odor, not unlike that of tarred paper. It is used in various ways as an insecticide, but most commonly as camphor is used, that is placed with objects liable to the attacks of moths. Used in this way I am satisfied after a thorough trial of more than a year that it is valuable in repelling moths. They do not like the odor and seek some less highly perfumed locality for their eggs. It is not however unfailing as I have a few times found moths in cases the air of which was strongly impregnated with the Naphthaline. I have had greater success in keeping moths from one or two museum cases containing fur and woolen objects by using this substance than with any other of the numerous articles that have been tried. Of course the best way to destroy moths, in cases and the like is to never let them get into them, but sometimes, as most who have had the care of a museum know, they succeed in getting at favorite objects and in such cases, after spraying with bisulphide of carbon, a few cakes of Naphthaline may be left among the most affected specimens. For use in chests, closets and the like Naphthaline has the advantage of not producing a dangerously inflammable vapor nor one which is so disagreeable in its odor. It has the disadvantage of being persistent which is also an advantage in that its action is continuous, not as in case of the volatile substances very temporary.

Pyrethrum.—In addition to what has been said of this substance in former articles which subsequent experience does not lead me to modify, it may be worth while to mention the result of experiments which have been made with the dry powder in one of the above museum cases infected with moths. It was not found of much value as it neither destroyed nor drove away the moths to such an extent as to warrant its further use. It did check their ravages somewhat, I think, but, used as it has been reported to me, in woolen chests and elsewhere, to destroy or keep away moths, it is of very little if any value.

Cedar Chips, Sawdust, etc.—It has long been supposed that the wood of the common red cedar was, by reason of its odor, offensive to moths, and therefore that scattering chips or sawdust of this wood among woolen articles would effectually prevent the ravages of moths, and especially if chests, drawers or closets are lined with red cedar do the moths avoid them. What is the origin of this widespread belief I do not know, but it certainly has very little foundation in fact. If red cedar is in any way disagreeable to clothes moths, which I doubt, it is not a sure preventive, and the expense which is sometimes incurred in lining drawers, etc., with the wood is wholly needless. I have seen moths in all stages crawling about amidst the cedar sawdust quite indifferent to its presence. It may be incidentally noticed that camphor is not effectual, though more so than cedar. None of these materials are so good as napthaline.

MAPLE SUGAR.*

By J. L. HILLS.

It is a well-known fact that as one ascends from the sea level the boiling point of a liquid falls, the drop in the case of water being one degree F. for each 533 feet rise in altitude. This becomes a matter of interest in connection with the use of the thermometer in maple sagar making with a view of obtaining the government bounty, for the sugar bushes of Vermont lie from two hundred to two thousand feet above sea level. In Bulletin No. 26, this Station recommended heating syrup to certain definite degrees in syrup and sugar making. The bulk of the work on which these recommendations were based was done at about 500 feet above sea level, and a further series of tests have since been made to test whether differing altitudes would alter results. These tests seem to indicate that *if sugaring off at higher altitudes than 500 feet above sea level does materially affect the grade of syrup or sugar made at the temperatures prescribed in Bulletin No. 26, the alteration will tend to improve the grade.*

These latter tests were carried out as follows:

Ten gallons of good and ten gallons of medium quality syrup were each divided in four lots of two and a half gallons each. Two lots of each quality were sugared off at about 400 feet, one lot of each at 1000, one lot of each at 1600 feet above sea level. We thus had the same syrups sugared off in the same pan by the same person, at different altitudes. Samples for analysis were taken in duplicate, as the boiling syrups arrived at 218°, 220°, 225°, 230° and 235°. The boiling points of water and the two syrups at the various altitudes and the barometric pressure at each half hour during boiling were carefully taken, the latter by means of a delicate aneroid barometer. At the same time similar observations were made on the standard mercurial barometer at the Experiment Station. By calculation from the data afforded by the two instruments the altitudes of the places at which sugaring off was done were easily obtained. The weather was remarkably clear and uniform throughout the tests and there was little or nothing but changing altitude to affect the aneroid.

The work was done at the Experiment Station, Burlington, and at the residences of Hon. Victor I. Spear and Mr. F. H. Packard, Braintree. The thanks of the Station are due these gentlemen for their assistance and courtesy.

A few samples were lost by unavoidable accident, but 120 polarizations were made on samples taken, and they with other data may be summarized as follows:

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*This should be read in connection with the rules for temperatures on page 24.

Location.	Ex. Station.	Mr. Spear's.	Mr. Packard's.
Altitude above sea level......(feet)	375	1025	1585
Water boiled at..................(°F)	212-	210½	210
Syrup No. 1............ ......(°F)	218	217-	216
“ 2...................(°F)	217	216	216-
“ 1 average percentage ..	71.61	71.68	72.11
“ 2 “ “ ..	65.93	66.19	67.80
“ 1 per cent sugar @ 225°	71.56	72.42	73.47
“ 2 “ “	65.18	66.66	68.35

The average percentage is obtained by adding percentages obtained at the five various degrees and dividing by five. It is much the same as results at 225° which is about midway between boiling and sugaring off point. Three thermometers, two chemical standard and one sugar, were used in this work, all agreeing within a fraction of a degree at points between 212° and 235°.

The theory of the effect of increasing altitude on boiling point, and sugar percentages, may be stated as follows:

If a syrup boils at, say 218° at the sea, at 1000 feet higher it might be expected to boil about two degrees lower, say 216°. At the higher altitude the syrup boiling at 216° will have lost by evaporation more or less water when the temperature rises to 218° and be consequently richer in sugar than the same syrup just starting to boil at 218° at the sea level. The same reasoning applies throughout the degrees, a syrup boiling at 235° at the higher level being theoretically of the same quality as the same syrup boiling at 237° on the lower level.

Referring to the tabulation we find that the lowering boiling points of water and syrup and rising average per cent of sugar in passing from 375 to 1585 feet above sea level, bears out the theory. The individual analyses in the upper degrees (225-235°) also coincide with theory in the main, while in the lower degrees they are somewhat irregular. This irregularity may be explained by the fact that the thermometer may rise slowly at first so that many minutes brisk boiling may ensue without change, while on the other hand it may change a degree in a minute. Whether samples be taken at once on the arrival of the mercury at the stated degree or later, may easily effect results.

Both theory and experiment appear to indicate that the higher the richer, if the same temperature be used. Hence it follows that if the directions given in Bulletin No. 26 be correct and will make an 80 per cent sugar and an eleven pound syrup at Burlington they will the more certainly do it at higher points, and that if a degree temperature be subtracted for each five hundred foot rise, the results may be expected to become more closely like those obtained on a lower level.

It should not be forgotten that other factors, such as weather, quality of syrup, method of manufacture, character of the sugar bush, etc., enter into the problem. But our work seems to show that the united effect of all of these cannot influence the result more than about one degree of the thermometer, so that they can be practically ignored by the sugar maker.

A word in closing about *thermometers.*

There are several makes on the market, some well, and some ill adapted, some correctly and some incorrectly marked, as to the proper degree for syrup and sugar. There have been a good many sent to the Station for testing, of several makes, and we found *more wrong than right.* The error was low, being from 1 to 10 or more degrees.

An incorrect thermometer may be safely used if the nature and amount of error is known, and the sugar makers of the State are urged to test their thermometers before using. A sugar maker may get a close idea of the correctness of his thermometer by immersing it in boiling water, letting it stand thus a few minutes before reading. Immerse as in sugaring off, use soft water and protect from drafts, This will give the boiling point of water at the locality where it will be used, Subtract or add according as it registers more or less than 212°, and similarly modify for local altitude, conditions and incorrect thermometer the degrees as prescribed in Bulletin 26. If possible it will be best to test before buying and make sure that the instrument is correct.

The Experiment Station will test all sugar thermometers sent it, express or mail prepaid, free of charge. They should be securely packed; several recently sent have been broken in transit.

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